DEPARTMENT OF THE INTERIOR

REPORT

OF THE

CHIEF ASTRONOMER

BEING PART IX. OF THE ANNUAL DEPARTMENTAL REPORT

FOR THE

YEAR ENDING JUNE 30

1905

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REPORT OF THE CHIEF ASTRONOMER.

THE OBSERVATORY,
OTTAWA, December 30, 1905.

W. W. CORY, Esq.,
Deputy Minister of the Interior,
Ottawa.

SIR,—I have the honour to submit the following report upon the operations of the Astronomical Branch of the Department during the past year. The correspondence of the branch from July 1, 1904, to June 30, 1905, was as follows:—

Letters received (exclusive of circulars, &c.)	1,138
Letters sent " "	1,871
Accounts dealt with	498

The correspondence, as now classified, is all contained on 285 files, representing subjects of correspondence. A card index, alphabetically arranged according to subject, forms a ready reference to the files. An incoming letter book and an outgoing letter book are kept for the record of the correspondence. The accounts are kept in an accounts record, from which they are posted into a card system ledger, classified under 45 titles, representing the principal items of expense connected with the administration of the branch.

The expenditure on the astronomical work and the boundary surveys, including salaries of all temporary employees, between July 1, 1904, and July 1, 1905, was $92,999.73.

THE DOMINION OBSERVATORY.

In my last annual report, I spoke of the expected completion at an early date of the Dominion Observatory. The building was ready for occupation and partly furnished by Easter, when the branch, comprising the staff of the chief astronomer and the boundary surveys, moved into the new building, vacating the rooms at 26 Wellington street which it had occupied for a few days less than nine years.

The new building is found very suitable for its purpose, affording space, which in the former quarters was very deficient, for the systematic carrying on of the work, including the correspondence, computing, draughting and photographing. The location of all the instruments in the same building is also most advantageous for the prosecution and supervision of the observations, as contrasted with the former condition of things. Accommodation for the library, which was much needed, is also provided. The shelving for the books has lately been put in, and the cataloguing is being proceeded with. Good progress has been made since our occupation of the building towards the completion of the furnishing and the installation of the instruments. The permanent accommodation for the meridian instruments is, however, not yet quite ready. The contract for the erection of the 'transit house' to receive these instruments was let early in the season. This house forms an annex to the western end of the present building, and is now nearly completed. It is proposed to place in it a meridian circle, which is now being constructed at the works of Messrs. Troughton & Simms. Accommodation is also provided in this building, by two piers, for the port-

able transit instruments used in longitude determinations, or other instruments as may be requisite. Pending the completion of this building, temporary shelters for the field transits have been provided to the east of the main building.

Descriptions of the various instruments now in use will be found in the reports and statements annexed.

It may be stated here that the observatory is open to the public every day during office hours, to view the building and the instruments. In addition every Saturday evening visitors are allowed, under the supervision of one of the staff, to view the celestial bodies through the fifteen-inch equatorial telescope. These privileges are taken advantage of by many people. The number of people registering their names in the 'visitors' book,' from May 31 to October 31, was 2,666.

ORGANIZATION OF STAFF.

With the removal to the new building, a proper organization as a branch of the Department became necessary, involving the permanent appointment of a sufficient staff to carry on systematically the work of the observatory and the boundary surveys. Provision having been made by parliament, the existing permanent staff, comprising only myself and Dr. Klotz, was added to by the appointment on July 1 of twelve officers. The names of the staff as thus constituted, with their respective duties, will be found in an appendix hereto.

ELECTRIC CLOCKS.

An appropriation of $5,000 was made by parliament in the session of 1904 for the installation of electric clocks in the government buildings. As mentioned in my last annual report, the primary clocks of the experimental system had been housed in the basement of the Supreme Court building on Bank street, with a connection with the Cliff street transit-house. All this apparatus has been moved to the new building, including the instruments which were at Cliff street. An arrangement has been made with the Bell Telephone Company for the use of wires connecting the observatory with the principal government buildings. Master clocks and dials have been installed, and the whole system is now being worked from the primary clock at the observatory.

There are now being operated in the parliament building, 42 dials; in the west block, 60; in the east block, 36; in the Langevin block, 48; at 26 Wellington street, 2; and in the observatory, 26, besides a tower clock; or in all 214. There is also a circuit for dropping the time ball on parliament hill. This has lately been put in operation. The dials are driven by master clocks, which are in turn synchronized by the primary clock at the observatory, which itself is regulated by observation.

With regard to the synchronization of the master clocks, it has been found advisable to make a modification. In the experimental system, the pendulums of the controlled clocks had their oscillations checked by a damping cylinder. This gave a very perfect control, but had the fault that in case of interruption of the controlling current for a short time the damper would bring the pendulum to rest and stop the clock with the dials depending upon it. This method of synchronization has been replaced by another in which the damping is omitted. In case of interruption of the synchronizing current, the controlled clocks are no longer subject to stoppage; they continue to work as independent clocks irrespective of the interruption. This control, though theoretically less perfect than the other, is sufficient for the purposes of time service by dials moving every minute. A full description of the instruments used in the time service, by Mr. R. M. Stewart, who has charge of them, is appended.

LATITUDES AND LONGITUDES.

The determination of latitudes and longitudes of points in Canada has been continued. On this work have been employed Dr. Klotz, Mr. F. A. McDiarmid and Mr. R. M. Stewart.

Dr. Klotz early in the season engaged in a determination of the difference of longitude between Vancouver and Seattle, in conjunction with the United States Coast and Geodetic Survey, represented by Mr. Smith, who observed at Seattle, while Dr. Klotz observed at Vancouver.

The purpose of this determination of longitude was as follows:—

In 1896, the difference of longitude between Montreal and Ottawa was determined in the usual way by Prof. McLeod of McGill University and myself. The longitude of Montreal had been determined by connection with Greenwich and with certain points in the United States. By combination of these observations a presumably accurate longitude had been obtained by the late Mr. Schott in his computation of the 'United States longitude net.' From this longitude that of Ottawa was obtained by addition of the difference observed in 1896.

From this again the longitude of Vancouver was obtained by a difference of longitude observed in 1900, by Dr. Klotz and myself.

From Vancouver the longitude was extended to Australia and New Zealand by a series of steps by Dr. Klotz and Mr. Werry, in 1903.

Such a series depends for the accuracy of any longitude upon the accuracy of all steps behind it. The errors are very small individually, but their accumulation is to be guarded against. For this reason it is not advisable to depend for longitude upon a mere chain, but cross connections are needed by which a longitude may be determined from as many independent points of known longitude as possible. The aim is to form triangles or 'nets' in strict analogy with the methods of trigonometrical surveys.

By connection with the United States longitude net is known the longitude of Seattle, which thus affords a convenient point from which to get a second determination of the Vancouver longitude. This it is important to determine with accuracy as the basal point not only, as explained above, for the transpacific longitudes, but also for longitudes in Yukon Territory, and possibly the international boundary at the 141st meridian of west longitude.

In this work Dr. Klotz used the 'Repsold' or registering micrometer attachment to the transit instrument, a recent device, a description of which will be found in his report appended hereto.

This apparatus is believed to increase the accuracy of observation, and especially to eliminate the 'personal equation' of the observers, thus saving half the time and cost of a longitude determination.

The movable thread in this micrometer is moved by hand, the observer endeavouring to keep the star bisected throughout its passage across the field of view. By an electric device automatic record is made on the chronograph of the times at which the thread passes certain points in the micrometer frame. The objection will at once occur to one who has had experience in transit observations that on a partially cloudy night, the star may be observed during part of its passage across the field of view, and yet a complete transit (20 records) be recorded.

It is said, however, that it is easy to distinguish these false records from the true, owing to the greater irregularity of the intervals between successive records. Nevertheless it is conceivable that an observer might become so expert in his use of the instrument that no irregularity of intervals should appear although the star was actually invisible at the recorded instants. In the micrometers moved by clock work which have been proposed as improvements upon the hand-moved Repsold, the danger from this cause would be still greater. There seems to be imposed upon the observer with this micrometer the duty, on partially clouded nights, of keeping a record of the visibility of stars while crossing the field of view, from which his observations may be properly weighted.

For the purpose of further strengthening the Canadian longitude chain, a determination was made later in the season of the difference of longitude between Harvard College observatory and Ottawa. Dr. Klotz observed at Harvard, and Mr. R. M.

Stewart here. Mr. Stewart not having a registering micrometer on his transit instrument, the personal equation between the observers was observed afterwards at Ottawa.

In the interval between the Seattle and the Harvard observations, Dr. Klotz observed at Father Point and Tadousac for latitude and longitude, Mr. Stewart assisting in the longitudes by taking the corresponding observations here. These observations were made at the request of the Hydrographic Branch of the Department of Marine and Fisheries.

From Tadousac, time signals were sent on August 1 to Sir Wm. Macgregor, at Chateau bay. These he had asked for for the purpose of determining longitudes on that coast, and especially in connection with the expedition sent from Lick Observatory to observe the total eclipse of August 30, at Sandwich bay. After the eclipse, signals were again sent him on September 1, directly from Ottawa.

Mr. F. A. McDiarmid has observed the latitudes and longitudes of twelve stations in Ontario and Quebec. This I believe to be a record performance, though the honours must be shared by Mr. Stewart who occupied the home station while the exchanges for longitude were being made, besides attending to his work in connection with the time service.

The stations observed by Mr. McDiarmid were, Sharbot Lake, Ste. Anne de Bellevue, Trenton, Madoc, Lindsay, Kingston, Whitby, Sutton, St. Catharines, North Bay, Temagami and Renfrew. These stations were observed for cartographical purposes at the request of the geographer of this department and of the intelligence division of the Militia Department. Besides this the difference of longitude between the transit house on Cliff street and the observatory was observed by Mr. McDiarmid and Mr. Stewart. The Cliff street house has been the reference point of all longitudes observed up to the present year. As the reference point will now be the observatory, this longitude connection was a necessity to correlate future longitudes with the past.

It seemed advisable further that an independent connection between the two points should be made by survey. As the two stations are not intervisible, the survey had to be carried out by a triangulation extending to the hills north of the Ottawa river, so as to secure points from which both stations could be seen. The angles of the triangulation have been observed by Mr. H. Bigger.

TRIGONOMETRICAL SURVEY OF CANADA.

Early in the summer a request was received from the Department of Militia and Defence that this branch should undertake the execution of a triangulation for topographical purposes of this part of Canada.

As the base line measurement and the expansion therefrom necessary for the observatory connection would serve for the initiation of the larger scheme, I was authorized to proceed with the latter tentatively, as a part of the work of determination of geographical positions hitherto done by us exclusively by astronomical methods, and pending specific provision by parliament for such a survey. A reconnaissance covering 3,000 square miles in the neighbourhood of Ottawa has been made by Mr. C. A. Bigger and Mr. J. D. McLennan and the selection and preparation of the observing stations has been begun.

TOTAL ECLIPSE OF THE SUN.

On November 19, 1904, the secretary of the Royal Astronomical Society of Canada communicated to the Right Honourable the Prime Minister, the following resolution of the council of that society:—

'In view of the fact that on August 29, 1905, there will be a total eclipse of the sun, first visible on the shores of James bay, and that it is in the interests of physical and astronomical science that the phenomenon be observed as fully as possible and reported upon; and the further fact that already the government of the United States

and the governing bodies of Lick Observatory and the Carnegie Institution have determined to send parties of observers to different parts of Canada.

'Be it requested of the government of Canada that steps be taken to organize an expedition, under its control, to proceed to the neighbourhood of James bay, the coast of Labrador, or other suitable place, to observe and report upon this eclipse.

'And be it further requested that a limited number of members of the Royal Astronomical Society of Canada who are qualified observers shall be granted the privilege of accompanying the expedition, free of expense to themselves, the extension of such a privilege to a national astronomical society being entirely in accord with the custom which has obtained in all previous eclipse expeditions despatched by Great Britain and other countries to foreign parts.'

In compliance with the request of the society, the sending of an expedition to observe the eclipse was authorized by council. I was put in command, and invitations were given to six members of the society to accompany the expedition. The conditions having later been found such, with relation to transport, &c., as to warrant an increase of the party, invitations were issued to Mr. Maunder, of the Royal Observatory at Greenwich, with Mrs. Maunder, and to others interested in astronomical science, to accompany the expedition. The observatory party proper consisted, besides myself, of Messrs. Plaskett, Macara, Gauthier and Near. Mr. Menzies, of the Magnetic Observatory, Toronto, accompanied the expedition as magnetic observer. Mr. Plaskett was given charge of the designing of the apparatus and the preparations for the observations which it was desired to undertake on behalf of the observatory, leaving the other gentlemen bringing instruments to arrange for their own observations. To Mr. Macara was assigned the duty of looking after transport and commissariat for the whole party.

The central path of totality passed over the southern end of James bay, across the northern peninsula to Lake Melville, thence easterly to Sandwich bay, on the Labrador coast, and to the Atlantic ocean. There were thus four localities which would be accessible by water, from which to make a choice. Long land travel in these wild regions would obviously be impracticable with a large expedition.

Taking into account all considerations, especially probable weather conditions, so far as known, a point on Lake Melville, at the mouth of Northwest river, was finally chosen for the location of the Canadian expedition.

The ss. *King Edward,* of Quebec, was chartered for the expedition. Leaving Quebec on August 4, Northwest river was reached on the 11th. Prof. Louis B. Stewart, of Toronto, had preceded the expedition, travelling via St. John's, Newfoundland, and by the Labrador steamer, for the purpose of selecting the best place for the instruments and for the camp. Arriving at Northwest river a few days before the expedition, he was fortunate in finding an excellent place near the Hudson's Bay Company's post.

Here the expedition landed, and after much labour the installation of the instruments was completed some days before the eclipse, which gave time for the necessary practising and accurate adjustment.

The ss. *King Edward* returned to Northwest river, according to arrangement, on August 28, bringing several gentlemen who had been invited to join in the observations.

On the 29th a strong easterly wind prevailed, bringing cloudy skies. This weather continued during the night and the next morning dense clouds obscured the sun throughout the time of the eclipse. Totality, which occurred a few minutes before eight o'clock, was marked only by the dense darkness, and the careful preparations for photographing were rendered nugatory.

It had been hoped that good photographs of the corona would be obtained on this side of the Atlantic, which by comparison with those taken in Spain and Africa would afford information as to the variations of form, during the elapsed time, of the little-understood corona.

Unfortunately the expedition sent out by the Lick Observatory, which was stationed at Sandwich bay, some 100 miles eastward from us, was equally unsuccessful.

Immediately after the eclipse the work of packing up and loading on the steamer was begun. This was completed on the morning of September 1, and the *King Edward* started on her return voyage. Quebec was reached on September 7.

The equipment of the various observers and the objects aimed at was as follows:—

The instruments and proposed observations of the observatory party are fully described by Mr. Plaskett in his report.

Mr. Maunder, representing the Royal Observatory at Greenwich, was equipped as follows:—

1. From the Royal Observatory, Greenwich.

(*a*) 'Dallmeyer Coronagraph,' aperture, 4 inches; focal length, 5 feet; used with negative enlarger so as to give image of sun 2·4 inches in diameter. Mounted on equatorial stand of a 6-inch telescope by Simms. Programme, 6 exposures — 5 seconds, 10 seconds, 20 seconds, 20 seconds, 10 seconds, 5 seconds. To correspond as nearly as possible with the 'Thompson coronagraph' being used at Sfax in Tunis, in this eclipse; and to continue the series of coronal photographs taken in former years; this Dallmeyer coronagraph having been used in Mauritius in 1901.

(*b*) 'Abney' lens. A rapid rectilinear lens, 4 inches aperture, 34 inches focal length, photographs taken in primary focus. Mounted on equatorial stand of telescope of 4 inches aperture, lent to Greenwich observatory by Mrs. Maunder. Programme as for 'Dallmeyer' corónagraph. Corresponding to similar lens being used at Sfax, and to lenses used in eclipses of 1900 and 1901. Intended to secure the outer extensions of the corona, whilst the Dallmeyer coronagraph was intended for the details of the inner corona.

2. Mrs. Maunder's apparatus.

(*a*) Cooke photo-visual telescope, aperture, 3½ inches; focal length, 4 feet. Lent to Mrs. Maunder by Messrs. T. Cooke & Sons, of York. Mounted on 'Matthew' equatorial stand, belonging to 4-inch telescope, lent by Royal Astronomical Society to Mrs. Maunder for this eclipse. Programme 10 exposures in primary focus, varying from half second to 4 seconds. To correspond with series obtained in Mauritius with similar instrument in 1901.

(*b*) Dallmeyer stigmatic lens, 1½ inches aperture, 9 inches focal length, mounted on miniature equatorial lent by Royal Observatory, Greenwich, to Mrs. Maunder for this eclipse. Programme 4 exposures in primary focus, 15 seconds, 30 seconds, 30 seconds, 15 seconds. To obtain the long streamers. Same lens that secured the long streamers in 1898, and was used also in 1900 and 1901.

(*c*) Goerz anastigmat lens, 2 inches aperture, 2 feet local length, fixed mounting. Lens lent by Messrs. Goerz, of Berlin, who also lent a similar lens to Prof. H. H. Turner to use in Egypt in this eclipse, so as to give, with the photographs to be taken in Labrador,, a set of stereoscopic pictures of the corona. Programme, 6 exposures, each of 0·4 seconds duration, with plates of different sensitiveness.

In the eclipse it was intended that the telescopes should be worked as follows:—

'Dallmeyer' coronagraph, Mr. Maunder.
'Abney' lens, M. Jennings.
Cooke photo-visual, Mr. Upton.
Stigmatic lens and Goerz lens, Mrs. Maunder.
Time keeper, Mr. Russell.

Mr. Menzies, as magnetic observer, was provided with the following instruments:

Magnetometer for recording photographically daily curves of horizontal force and declination.

Elliott magnetometer for determining absolute declination and horizontal force.

Dip circle for determining inclination.

Air barometer for recording small changes of pressure.

Standard barometer and thermometer for comparisons.

Richard thermograph, self-recording with pen.

Mr. Louis B. Stewart used a ten-inch theodolite for the determination of latitude. He also determined longitude by transits and azimuths of the moon with this instrument, as well as by carriage of chronometers. He made gravity observations with the Mendenhall half-seconds pendulum, and a survey of the station to show the positions of the various instruments.

Rev. I. J. Kavanagh, S.J., reports as follows upon his proposed observations for the purpose of charting the extreme coronal appendages:—

'Though our low-lying station on the Nor' West river in Labrador did not present the best conditions for the observation of the coronal streamers on account of the large atmospheric absorption, no means were neglected to secure records of their form and direction for comparison with the data elsewhere to be obtained. The fact of our station being the very first, as that at Assouam was the last, in the path of the lunar shadow, gave a special value to observations made at this point. Moreover, the increased solar activity in this maximum sun-spot period, made it very probable that there would be notable variations in the coronal appendages.

As the photographic method could not, in the given time, secure the dimmer and more delicate streamers, or pursue to their furthest extremities the more substantial rays, the shortcomings of this process were supplemented by the instantaneous method of unaided visual observation and simultaneous charting.

Fine seeing being all important in this work, the eyes of the observer were to be lightly bandaged for a quarter of an hour before totality, and during it, to be protected from the glare of the lower corona. This last was effected by the use of a light sighting-rod fastened to an altazimuth telescope provided with slow motion. A thin board, blackened on one side and white on the other and pierced by a quarter-inch hole, constituted the eye-piece. At the end of the rod, 10 feet away, was an opaque disc of a size calculated to cover the moon and four minutes of arc beyond. An assistant, Mr. H. M. S. Cotter, of the Hudson's Bay Co. post, was, by means of the slow motion, to keep the shadow of the disc on the eye aperture of the board, which, on this side, was covered with white paper to facilitate the operation. This adjustment was to have commenced some time before totality, and, even if the shadow of the disc were too indistinct to be followed, it might have been carried through the few moments of totality by a regularly continued handling of the slow motion. The telescope was in adjustment, but was to be used only at the end, for the glare of the corona falling on the eye would spoil it for fine seeing.

The charting to scale was to be done on a light blue paper on which the pencil marks would be just visible in dim light. In the centre was a black disc the size of half a crown, and all around a series of concentric circles, the disc's diameter apart. These half-crown dimensions have been suggested and widely adopted in view of securing a uniform scale for such drawings. At the several stations set up in Spain by the Jesuit Fathers this observation was, in each case, confided to five people; one for each quadrant and one to supervise the whole.

In remote preparation for this observation a considerable amount of practice in special drawing was absolutely necessary. For this purpose, several diagramatic sketches were made on dark paper. A black disc, five centimeters across, represented the moon, while the corona and streamers of varied intensity, form and length were drawn in white chalk, some of them extending 30 or 40 centimeters. The diagrams were placed in a dim light about 5·5 metres away, so that disc subtended the same angle as the moon on the eclipse day. These diagrams were copied over and over.

Excellent practice was also had on the streamers of the aurora borealis; the quick changes, both in form and intensity, of these capriciously shifting rays provided the best of drill in rapid and accurate charting.'

Rev. Dr. Marsh, of Hamilton, reports as follows upon his apparatus and that of Mr. G. Parry Jenkins.

'In my own charge were the following instruments:—

'1. A five-inch Brashear reflecting telescope of 75 inches focal length on equatorial mountings, clock driven, equipped with an enlarging apparatus giving an image of

the sun of two inches in diameter, with which I proposed to photograph the partial phases of the eclipse, making a special effort to secure a photograph when the shadow of the moon's limb came in contact with solar spots, thus obtaining a comparison of the relative darkness of the moon's limb with the sun spots.

'With this arrangement I also intended making two short exposures during totality to obtain if possible the inner corona; after which I had adjustment to immediately reduce the camera to its prime focus, and by making exposures of various lengths, I hoped to photograph the outer coronal streamers. If successful I intended to enlarge the latter to the same size as the photographs obtained with the enlarging apparatus and thus show the inner and outer corona on the same scale, and print them in the one photograph.

'2. With a two and an one-eighth-inch lens loaned me by Mr. Chas. Potter, of Toronto. This lens was mounted on an equatorial head loaned to me by Dr. King, and was fitted on a cement pier. This camera was provided with an enlarging apparatus making it 5 feet equiv. focus, and designed to photograph the inner corona and streamers. At my request Dr. A. S. Johnson, of Chicago, editor of the *Technical World* kindly undertook to handle this instrument.

'3. A 6-inch Gourlay compass transit which I had previous to the eclipse carefully adjusted, and with which I made observation for the magnetic variation which I computed to be 36 degrees 52 minutes, and with which instrument I also observed a fluctuation of 8 minutes during totality.

'4. I also used a registered thermometer and noted a drop of 2 degrees during totality.

'5. I also photographed the landscape during totality, giving one second exposure, and have pleasure in forwarding you a print.

'6. Three-quarters of an hour after totality I photographed a portion of the sun through a fleecy cloud with the 5-inch telescope, and beg to ask your acceptance of an enlarged print of the same.

'Mr. Jenkins had as follows:—

'1. A 3-inch Dollond refractor, mounted on an equatorial head, and equipped with a special enlarging apparatus for photographing both the inner and outer corona.

'2. A Bausch and Lomb camera, to which he fixed a Thorp's grating, and designed to take long exposure photographs of the sun together with two orders of spectra on a 5 x 8 plate. This instrument was fixed to Dr. Marsh's 5-inch equatorial, and was arranged to make two exposures of 90 and 45 seconds each.

'Mr. Jenkins successfully photographed the sun three-quarters of an hour after the eclipse, with No. 1 equipment and a photograph is being forwarded by himself.'

Dr. C. A. Chant, of Toronto, proposed to observe the polarization of the corona by visual observations with a polarimeter, and also by photography with a suitable camera.

Mr. J. R. Collins, of Toronto, proposed to take a succession of photographs of the sun from the beginning to the end of the partial phase. His telescope was of peculiar construction, a combination of refractor and reflector, designed and constructed by himself.

I had proposed for myself the observation by telescope of the times of contact, and of the general features of the eclipse.

BOUNDARY SURVEYS.

The re-survey and re-marking of the international boundary along the 49th parallel has been continued under the direction of Mr. J. J. McArthur, in co-operation with Mr. Sinclair, of the United States Coast and Geodetic Survey.

The work this year has been continued as in the past, by the two parties, Canadian and United States, working independently of one another, on different parts of the line, subject to mutual inspection and check.

Of the section of this line west of the Rocky mountains, 410 miles in length altogether, the part from the summit of the Rocky mountains to the Skagit river is now

practically completed and monumented. The line in the lower valley of the Fraser river from the Cascade mountains to the sea is also nearly completed. There remains to finish this section, some 40 miles west of the Skagit river, in the Cascade range.

Mr. J. M. Macoun has continued his investigations into the natural history of the neighbourhood of the 49th parallel west of the Rocky mountains, and Dr. R. A. Daly his geological researches. By order in council, Dr. Daly was transferred in July last from the Geological Survey to the Department of the Interior, thus carrying out the intent of his original appointment as geologist to the International Boundary Surveys.

The London Tribunal of 1903, in its settlement of the Canada-Alaska boundary question, failed to determine the mountains which should define the boundary line across the space between the peaks referred to as 'P' and 'T' in their Award. An agreement has since been come to between the governments of the United States and Great Britain, whereby the boundary line shall, across that space, be laid down in accordance with a joint recommendation made by Mr. Tittmann and myself in April, 1904. There is, therefore, now full authority for the survey and marking of the whole boundary line from Cape Muzon and Mt. St. Elias.

The survey of this boundary line, commenced last year jointly with the United States, has been continued during the present season. Mr. C. A. Bigger has had general charge of the field work of the Canadian parties.

The distribution of the survey work on this line has been as follows:—

Canadian survey party working northwesterly from the head of Portland canal, Mr. Geo. White-Fraser, D.T.S., in command.

In the region about the Unuk river, a United States party, under command of Mr. Fremont Morse.

In the region about the Stikine river, a Canadian party, under Mr. A. J. Brabazon, D.L.S.

In the region about the White Pass, a United States party, under Mr. Leland.

In the region of the upper Chilkat river, a United States party, under Mr. A. J. Flemer.

In the region of the upper waters of the Salmon river, a tributary of Chilkat river, a Canadian party, under Mr. W. F. Ratz, D.L.S. Mr. Ratz, after completing his work in this region, spent the rest of the season in a reconnaissance on the Taku river. In accordance with an arrangement which had been made with the United States commissioner, two surveyors were appointed by him to accompany the parties of Mr. Fraser and Mr. Brabazon. One Canadian representative, Mr. J. D. Craig, was appointed to accompany Mr. Morse's party. The chief office of these representatives was to insure satisfactory identification of the boundary peaks determined upon by the London Tribunal. Mr. Bigger assisted Mr. Leland in the identification of certain points at White Pass.

In June an informal suggestion was received from Mr. Tittmann that a joint examination be made of the monuments marking the boundary line between the state of Vermont and the province of Quebec. Such examination with a view to renewals and necessary additions of the international monuments is the settled policy of the Canadian government, as stated in the Order in Council of May 26, 1900, and shown by their subsequent action with regard to the New York-Quebec line, and the 49th parallel. The suggestion was therefore agreed to, and Mr. G. C. Rainboth, D.L.S., was appointed to carry it out in conjunction with Mr. J. B. Baylor, assistant in the United States Coast and Geodetic Survey, who had been detailed by Mr. Tittmann for the work.

As there seemed, when the Vermont section of the line had been gone over, manifest advantage in carrying the examination farther, it was continued so as to cover the whole of the land boundary between Canada and the United States, as far as the source of the St. Croix river, with the exception of the densely forested parts along the 'Highlands,' which could not be reached without the expenditure of considerable time and money. The work was completed a short time ago, and a report has not yet been rendered.

Appended hereto will be found the following statements and reports:—

Appendix 1.—Names and duties of permanent staff of the branch.

Appendix 2.—Report by Otto J. Klotz, LL.D., upon field astronomical observations during the season, to which has been added a description of the half seconds pendulum apparatus, and of certain observations therewith made in 1902.

Appendix 3.—Report by Otto J. Klotz, LL.D., on Transpacific longitudes between Canada, and Australia and New Zealand.

Appendix 4.—Description of the observatory building and instrumental equipment, by J. S. Plaskett, B.A.

Appendix 5.—Report of the expedition to observe the total solar eclipse, by J. S. Plaskett, B.A.

Appendix 6.—Description of the apparatus used in the time service, by R. M. Stewart, B.A.

Appendix 7.—Tabular statements of the observations for longitude made by this department from 1885 to 1904.

Appendix 8.—Report on field operations in the geology of the mountains crossed by the international boundary (49th parallel), by R. A. Daly, Ph.D.

I have the honour to be, sir,
Your obedient servant,

W. F. KING,
Chief Astronomer
and International Boundary Commissioner.

APPENDIX 1.

PERMANENT STAFF OF THE ASTRONOMICAL BRANCH, DEPARTMENT OF THE INTERIOR.

W. F. King, B.A., LL.D., D.T.S., chief astronomer.

CORRESPONDENCE AND ACCOUNTS.

W. Simpson, secretary and accountant.
J. H. Labbe, correspondence clerk.

OBSERVATORY DIVISION.

Otto J. Klotz, LL.D., D.T.S., astronomer.
J. S. Plaskett, B.A., astronomer.
J. Macara, chief computer.
Louis Gauthier, C.E., keeper records.
F. W. O. Werry, B.A., D.L.S., observer.
F. A. McDiarmid, B.A., observer.
R. M. Stewart, B.A., observer and superintendent of time service.
W. M. Tobey, B.A., observer.
J. D. Wallis, photographer.

BOUNDARY SURVEYS DIVISION.

J. J. McArthur, D.L.S., surveyor.
C. A. Bigger, D.L.S., surveyor.

APPENDIX 2.

OTTAWA, October 7, 1905.

W. F. KING, Esq., B.A., LL.D., D.T.S., &c.
Chief Astronomer, Department of the Interior,
Ottawa.

SIR,—I have the honour to submit the following report on the longitude and latitude work carried out under my charge during the season of 1905; also of the pendulum observations made by me in Washington and Ottawa with the half-seconds pendulum apparatus.

I have the honour to be, sir,
Your obedient servant,

OTTO J. KLOTZ.

REPORT UPON FIELD ASTRONOMICAL OBSERVATIONS AND DESCRIPTION OF HALF-SECONDS PENDULUM APPARATUS.

In view of the future determination of the position of the 141° meridian, part of the international boundary between Alaska and Canada, it was desirable that a connection be made between Vancouver and Seattle.

Accordingly I left in May, with the astronomic outfit, for Vancouver. Before beginning work I proceeded to Seattle to confer with Mr. Edwin Smith, the officer of the United States Coast and Geodetic Survey, about our programme for observations, and also about the necessary telegraphic facilities for exchange of time signals at night. The Seattle observing station is on vacant ground near the old university building, now used as a public library.

In Vancouver, I occupied our observatory at Brockton Point, Stanley Park.

My astronomic outfit was the same as that used by me in the transpacific longitude work, with the exception of the transit micrometer, to be described later.

The transit Cooke No. 3 is by T. Cooke & Sons, and known as No. 504 of their catalogue, 1900, with slight modifications ordered by this office. It has an object glass of 3 inches clear aperture, and 36 inches focal length; axis 1¼ inches in diameter, Y's 1[illegible] inches in width, and the support of the axis is on two cylindrical segments of ¾-inch long arc each.

The telescope is provided with two 6¾-inch setting circles reading by verniers to 20 seconds of arc. One of these circles is provided with a special arm for carrying the latitude level, when using the instrument as a zenith telescope. Above the level there is a device for an attachable mirror, a strip of silvered glass set in a metal frame. In using the transit as a zenith telescope the level readings cannot be satisfactorily read for stars near the zenith, as one end of the bubble will be directly behind one of the transit standards. To avoid parallax in reading the level, the mirror, secured at an angle of 45°, and at the height of the eye, overcomes the difficulty. A dew-cap, 6 inches long, is used when observing.

A striding level is provided, one division equivalent to $\cdot 08^{sec.}$ The vial rests on cork tips and is retained in position by light cork-tipped springs, one at each end.

There is a glass covering to prevent sudden change of temperature of the vial. A single wooden knob on the level frame serves for handling the striding level.

The illumination of the field (threads) is now effected through the hollow axis by small 5-volt ground glass electric lights, placed on the lamp stands, attached to the transit standards. These lights are a great convenience and improvement on the oil lamps hitherto used, besides there is no heating of the axis. The necessary current is supplied for each light by three Columbia No. 6 dry cells. The lights were turned off when not required, as they readily burn out, if left burning continuously. For reducing the light there is a movable disc, with a circular reducing aperture, attached to the lamp stand and close to the lens in the axis.

The transit is supplied with reversing apparatus, operated by a lever, along and outside one of the standards.

The heavy cast-iron stand rests on an iron base-plate, and is supported by three large screws, one at one end and two at the other, fitting into spherical holes in the base-plate. For meridional adjustment two opposing screws at the foot of the stand, and near the supporting screws, act on a projection on the base-plate, which is immovable. The levelling is done by the single supporting screw at one end. The base-plate was not bolted to the pier, as the weight of the whole instrument and plate was sufficient to retain the latter in a permanent position with reference to the pier.

Dent sidereal chronometer, No. 48419, was used throughout the season's work. It is provided with a break-circuit wheel, making breaks at every even two seconds, omitting, however, the 58th second, in order to identify the minute.

A record of the temperature of the chronometer was kept, by means of a thermometer within the box. One dry cell, Columbia, was found sufficient for the chronometer circuit, which was always independent of any other circuit. It is undesirable to have a heavy current passing through the chronometer as it is apt to blacken or burn the points of contact. The clock circuit was only on during the time of observing, i.e., several hours a day. The clock was wound daily at 6 p.m.

A Fauth (Saegmuller) barrel or cylinder chronograph was used. The cylinder is 6¾ inches long, and 4 inches in diameter. and revolved once in a minute, so that the linear measure between the two-second breaks is forty-two hundredths of an inch. A Waterman fountain pen attached to an arm on the armature answered the purpose of a recording style. By means of a finely divided glass scale, with divergent-convergent lines, with intervals of one-tenth of a second the record of the chronograph was read. The tenth second intervals on the scale were further subdivided by estimation to tenths thereof, so that the transits were read to hundredths of a second. The chronograph sheet covers about 1¼ hours in time, leaving a margin on each side for notes. Three dry cells were used for the chronograph circuit.

The switchboard which has been used for many years very satisfactorily, was used at every station. It contains two keys, one ordinary make-circuit telegraph key, and a break-circuit key used only for sending arbitrary time signals; a talking-relay (150 ohms); a split signal-relay; a pony clock-relay (30 ohms); a sounder, seldom used by expert operators; a switch to throw the main line circuit on or off the points of the clock-relay, when on, so that the clock beats can be sent directly over the main telegraph line to any distant station; the necessary binding posts for joining up the wires; and plugs for the various cut-outs.

The whole is mounted on a rosewood board 18 inches by 24 inches, hollowed out on the under side where the covered connecting wires between relays, switches, cut-outs and binding posts are exposed for ready examination.

For the exchange of time signals a telegraph operator would come to the observatory at a stated time, the main line would be 'cut in' on the switchboard, a few words would be exchanged between the two observers at the two stations about the condition of the sky, whereupon the desired number of signals would be alternately sent and received, and the services of the operator for the night were over.

Since the transpacific work, finished last year, the telescope has been provided,

also Cooke No. 2, with the registering or transit micrometer. It will be in place here to say a word about this attachment.

The essence of longitude work is accurate time determination. If we have an accurate time determination at two places and a comparison of these times by cable or telegraph, we obtain the difference of longitude between the two places. Hitherto time determinations have been made by observing the transit of a star over a number (11 with us) of threads placed in the focal plane of the telescope. The instant of passage over each thread was recorded on a chronograph by tapping an electric break-circuit key. From this it will be seen that a phenomenon (transit) suffered interpretation by the observer, and this interpretation is dependent upon the temperament of the observer, that is, upon his 'personal equation.' With experienced observers the personal equation is a fairly constant quantity during a season under normal conditions. This is equivalent to saying that an observer will habitually record the transit of a star too soon or too late by a certain quantity, a fractional part of a second.

This quantity does not affect the apparent accuracy of a time determination, judged by the residuals or probable error, nevertheless it affects the absolute time determination. Hence the difference of longitude between two places as determined by two observers is invested with the error due to the difference of their personal equations. This error is inherent to the method of observing transits over threads. The only way to eliminate satisfactorily this error is to exchange stations and instruments, and make another differential longitude determination, under the supposition that the personal equation of the two observers remains the same for both determinations. Evidently the mean of the two determinations will then give the absolute difference of longitude, and free from personal equation.

Longitude campaigns carried out under such conditions were made at a great sacrifice of time and money. This state of affairs has long been recognized by astronomers as unsatisfactory and expensive. The question was how to get rid of the personal equation in transit observations, so that transits could be recorded, practically free from the personality of the observer.

Repsold of Hamburg solved the difficulty by the invention of the 'registering' or, as I shall hereafter designate it, the transit micrometer.

The fundamental conception of this micrometer is that two observers do not differ in the bisection of a star by the micrometer thread, that is, if one observer bisects a star with the movable thread, the other observer would agree to the bisection, an assumption that may well be made within measurable quantity of time.

This being granted it remains to contrive a mechanism that will record this constant bisection, for as the star moves, the observer has to follow it across the middle of the field of the telescope where the registering is done.

Up to 1905 practically the only longitude work that had been done with the transit micrometer was the work carried out by the Geodätische Institut, Berlin, and the most notable determination is the classic work of Professor Albrecht and Mr. Wanach, in 1903, between Potsdam and Greenwich, in which the most elaborate pains were taken to obtain an absolute result. In order to prove the elimination of personal equation by means of the transit micrometer these two observers exchanged stations, and the two independent determinations agreed within the third place of seconds, that is, within a thousandth of a second of time. So that we now have the assurance by means of this micrometer to make longitude determinations without exchange of stations. From tests made at Washington Mr. J. F. Hayford, United States Coast and Geodetic Survey, is of the opinion that the result of three determinations of longitude made by means of the micrometer is equivalent in merit to that of ten nights, with exchange of stations, by the old method.

It will be observed, therefore, that the transit micrometer is a great acquisition to longitude determinations, in fact, it forms a distinct epoch for such work.

As our two transit micrometers were made by Saegmuller, of Washington, under the supervision of the Coast and Geodetic Survey, I can not do better than give a

description thereof as given (Appendix 8, Report 1904, U.S. C. & G. S.) by Mr. E. G. Fischer, Chief of the Instrument Division, with slight modifications:

Before considering the details of this micrometer, three points were determined upon as being essential to insure accurate and decisive action, durability and convenience in reading the chronograph record made by it.

First, it was decided that the mechanism of the slide carrying the wire should be of the form in which the screw is mounted in bearings at the extreme ends of the box or case holding the slide, the micrometer head being fast upon the end of the screw projecting from the box, because this insures greater stability under the side stress of the gears connecting the screw with the hand-wheel shaft than the form usually employed in theodolite and ocular micrometers, in which the screw is fastened to the slide and therefore takes part of whatever play there may be in the latter.

Second, it was decided that the electric recording device of the micrometer should be of the make-circuit form, transmitting its records to the chronograph, which is in the break-circuit of the chronometer, through a relay. This permits the use of a strong current through the contact points of the micrometer head, and therefore a minimum of pressure upon the latter by the contact spring.

Third, in order that the micrometer transmit no record except those made within an accepted space on either side of the line of collimation and forming the observations of the star transit proper, an automatic cut-out must be provided.

The micrometer box or case is 46^{mm} in length and 31^{mm} wide. Within it and near to one side is mounted the micrometer screw. Upon the latter fits, by a thread and cylindrical bearing, a rectangular frame forming the slide, which is 31^{mm} long and 23^{mm} wide. All play or lost motion, both of the slide upon the screw and the screw in its bearings, is taken up by means of a helical spring within the box, which, pressing from the inner end of the box against the slide and through it against the screw, holds the latter firmly against the point of an adjustable abutting screw, without impeding its free rotary motion. Upon the slide, at right angles to its line of motion, is mounted the single spider thread, which is used for bisecting the star during its passage across the field. Two threads, parallel to the line of motion about five time seconds apart, and mounted against the inner surface of the box, define the space within which the observations should be made. A short comb of five teeth, with distances equal to one turn of the screw between them, is also provided and indicates the four whole turns of the screw within which the observations are to be made. The diameter of the field of view through the Airy diagonal eyepiece, which has an equivalent focus of 15^{mm}, is something over 50 turns of the screw; thus giving a space of fully 23 turns of the screw on each side of the four turns in the centre of the field, so that equatorial stars are over a minute in the field before they reach the recording part.

That portion of the micrometer screw which projects through the box has the micrometer head fitted upon it, and secured in position by a clamp nut. The edge of this head graduated at the corner nearest the box to 100 parts (*a*, fig. 1, 2), also carries at its opposite corner a screw thread of three turns with a pitch of one millimeter and a diameter of 32^{mm} (*b*, figs. 1, 2). Sunk into the outer side of the head and fitted concentrically with it is a thin metallic shell, which has fitted upon it a hollow cylinder made of ebonite, 6^{mm} long and 26^{mm} diameter (*c*, fig. 1, 2). Five strips of platinum $0 \cdot 4^{mm}$ thick, *d*, and corresponding to the 12·5, 25·0, 50·0, 75·0, 87·5 division points of the graduation, *a*, are slotted into the edge of the ebonite cylinder, *c*, and secured in such manner as to make metallic contact with the micrometer head proper, and, through it, with the screw, micrometer box, telescope and telescope pivots and the iron uprights of the transit. By releasing the clamp nut within the ebonite ring, the graduated head, *a*, with its thread can be adjusted, in a rotary sense, in relation to the thread of the screw, and also of the spider thread upon the slide. At the same time the position of the platinum contact strips, *d*, can be set to correspond to the zero of the graduation, which latter is read by the index.

A small ebonite plate, secured to the micrometer box, carries upon its outer end, mounted in a suitable metal block, the contact spring, *f*. It ends in a piece of platinum turned over so as to rest radially upon the ebonite cylinder. Its width is 5 millimetres, and its thickness that of the contact strips, *i.e.*, 0·4^{mm}. A small screw, *c*, serves to adjust the pressure of the spring upon the cylinder. Against one end of the micrometer box is fastened a small bracket, upon which is centered a small worm wheel, *g*, gearing into the screw head of the micrometer head. It has 40 teeth, and moves one tooth for each turn of the micrometer head. The rim of a cup-shaped cylinder, *h*, which is secured to the worm wheel so that it can be turned and clamped in any position relative to the zero point of the micrometer head, has cut into it a notch, *i*, with sloping ends and of a length corresponding to four teeth of the worm wheel, or four turns of the micrometer screw. From the end of a lever, *k*, mounted against the side of the micrometer box, projects a small steel pin, *r*, reaching over the rim of the cylinder. The other end of the lever carries a small ivory tip, *l*, which rests upon the end of a spring, *m*, mounted on an ebonite plate and pressing at its middle point against a platinum-tipped screw, *n*. Whenever the small steel pin of the lever rests in the notch of the cylinder, the spring is in contact with the screw and allows the flow of an electric current through the coiled wires *o*, *p*, to the contact spring, *f*. But when the micrometer has been turned two revolutions to either side of the middle or zero position, and its motion is continued, the sloped ends of the notch in the cylinder will engage the lever, and through it force the spring, *m*, away from the screw, thus breaking the current. It will be seen, therefore, that this arrangement permits of the motion of the spider thread across the entire field without transmitting records to the chronograph, except during the four revolutions symmetrically disposed about the line of collimation.

Against the inner side of the micrometer head is fastened a spur wheel, *s*, with 40 teeth of 48 dimetral (inch) pitch into which gears the wheel with 80 teeth, *t*, mounted on the hand-wheel shaft. This shaft is supported by arms from the micrometer box. The hand-wheels, *w*, have a diameter of 40^{mm}, are 135^{mm} apart, and equidistant from the middle of the telescope, allowing ample space for manipulating in either position of the eye-piece.

The adjustment for collimation is made by means of a small screw, *x*, fastened to the micrometer box, which in turn is mounted by dovetail slides upon a rectangular frame.

As indicated in the description of the ebonite head, *c*, with its five platinum contact strips, *d*, the instrument itself is used as part of the electric conductor forming the relay circuit. The relay of 30 ohms resistance converts the make records into break records in the chronometer and chronograph circuit. From the binding post the current is carried by means of a rubber-covered wire along the telescope to and into the telescope axis, within the latter to an insulated metal cylinder projecting from the transit pivot. Each of the wye bearings of the transit has fastened to it an insulated contact spring, which, being connected with an insulated binding post at the foot of the instrument, establishes the circuit whether the telescope lies in an east or west position. Another binding post, screwed directly into the iron foot of the transit, affords a ready means for making the necessary connection to begin observations. A quick motion screw, *y*, carries the eye-piece across the field.

The above description serves for the micrometers of Cooke transits, No. 3 and No. 2. As these instruments are used also as zenith telescopes for latitude observations, the eye-piece with micrometer attachment is made movable through 90°, so that the vertical micrometer thread for transit observations becomes horizontal and adapted for measuring zenith distances. The value of one revolution of the micrometer, 100 divisions, is about 47″·5, so that, estimating a tenth of a division we obtain readings to ″·05. The whole number of revolutions of the micrometer is readily read from the teeth in the worm wheel, above described. There is a clamp

band or collar with two adjustable screws on the telescope immediately adjoining the micrometer attachment, and against one of these screws rests a steel screw bolt fixed on the micrometer attachment for the respective horizontal and vertical positions of the micrometer thread.

Last autumn when on an official visit to Washington, I had an opportunity to observe with the micrometer, and there obtained my first experience. The 'trick' to manipulate the micrometer is to follow the star by turning the two milled heads with the two hands respectively at a uniform motion, that of the star. The motion for different declinations of course varies. Polaris, for instance, moves about forty-seven times slower than a star near the equator. It is idle to think that absolute uniform motion can be given by hand, but experience shows that the irregularities fairly compensate each other. To every user of this micrometer the suggestion naturally makes itself to have a mechanism of some sort to turn the micrometer while the hand would simply correct any slight deviation as with the tangent screw and clock work of an equatorial. However, no such automatic device has yet evolved.

It may be stated here that our Cooke transits (Nos. 3 and 2) are of such weight and stability that the necessary touching of the hands to the milled heads on the telescope for turning the micrometer has not the slightest noticeable effect on the constancy of pointing of the telescope.

For the circuit of the micrometer four Columbia dry cells were used in conjunction with a 30-ohm relay of which the back points served to make the break-circuit necessary for record on the chronograph. Whenever the platinum strips, by turning the micrometer, came in contact with the stationary platinum spring, contact was made, the armature of the relay drawn to the core and hence the back points of the armature separated and the local chronograph circuit broken and a record made.

The programme of a night's work would consist in obtaining two independent time determinations by observing two sets of stars. Each set is composed of 14 stars, seven thereof being observed in the position of the instrument, clamp east, and sever in position clamp west. Of the seven stars one would be a polar, i.e., between declination 70° and 80°, the others would be time stars distributed between the zenith and equator. This gives fourteen observations to determine the three unknowns, clock error, azimuth and collimation. By a careful selection of the stars the sum of the azimuth and collimation factors may be made small, so that the errors of azimuth and collimation have little effect on the time determination.

It was so arranged that if the night was clear, the exchange of time signals would fall between the observations of the two sets and thereby, the effect of rate of the clock wholly or nearly eliminated. The reduction of the observations was made in the usual way, by least squares, that is, by forming three normal equations from the 14 condition equations and solving for the three unknowns.

The exchange of time signals was carried out in the following manner: Vancouver would send twenty arbitrary signals with intervals of about two seconds by means of the break-circuit key to Seattle, the signals being recorded on both chronographs, Vancouver giving a rattle to signify 'finished.' Seattle would then 'rattle' its beginning of signals, and send 40, closing with a rattle. Vancouver would then send another twenty signals. By this means the mean of the time of Vancouver sending would also be the mean of Seattle sending, thereby cutting out the differential rates of the clocks. This method was followed at all the other stations occupied during the season.

VANCOUVER.

At Vancouver I occupied our small permanent observatory (transit house) at Brockton Point in Stanley Park. During the past year a small office or work-room has been added to the building as well as the benefits and comfort of the waterworks system.

As on previous occasions here, the chronometer was placed in the brick-powder vault, near the observatory, being the most convenient and suitable place to insure a small daily range of temperature.

The first exchange of time signals Vancouver-Seattle was had on May 31, but no observations, due to clouds, were obtained.

The first differential longitude determination was obtained on June 8, when Mr. J. E. McGrath was observer at Seattle, having exchanged stations, Seattle-Sitka, with Mr. E. Smith. The Sitka longitude was carried on simultaneously at Seattle with the Vancouver determination.

There is one redeeming feature of the weather conditions in Vancouver and Seattle, and that is their relative proximity and situation on the sea-coast induces the same weather conditions to prevail, so that there is little or no unnecessary observing, as a mutually good night, or clear sky, is necessary for a successful longitude determination. By June 17 the requisite number of observations had been obtained.

FATHER POINT.

Having finished the Vancouver-Seattle longitude I returned to Ottawa and then proceeded to Father Point, Quebec. Here were built a brick and cement pier, as well as the 10-foot square observing hut on the property of J. McWilliams, immediately adjoining the lighthouse reserve. The centre of the pier is 125 feet 7 inches due south of the centre of the revolving light surmounting the lighthouse. The magnetic declination (July 6) was found to be 20° 55′ W. As usual the pier, 22 inches by 27 inches, was built on a cubic yard of grouting beneath the surface of the earth. The top of the pier is always made 30 inches above the floor of the hut, which is built of dressed flooring, tongue and groove, with the planed side inside. There is always a 2-foot clear opening in the roof, covered by two shutters extending longitudinally over the building.

The telegraph wire of the Great North Western was cut and led directly into the observatory, from where the necessary telegraphing for exchange of time signals was done at night. The length of line, Father Point to Ottawa, via Montreal, is 486 miles, and the signal exchange was very satisfactory, occupying only about five minutes of time. There was a repeater at Montreal. On the Ottawa-Montreal section of 120 miles, there were 120 volts, and on the remaining section 180 volts. At Father Point, where the St. Lawrence is 35 miles wide, considerable delay in getting the necessary observations was caused by fogs. A most marked, not to say extraordinary, phenomenon experienced was the very warm gusts of wind in the evening (10.30) of July 5 and again on July 7. Their duration was but a few seconds, and they appeared to come in narrow streaks from the south, where the banks of the river slope back to an altitude of several hundred feet. These warm (relatively hot) gusts would rapidly, for a short time, alternate with cool winds, or apparently cool ones, as the general temperature was low. The suddenness of the phenomenon and the high temperature was so marked, that I, facing the north outside of the observatory, quickly turned about, believing that a fire had been kindled near me. Was the phenomenon that of Chinook or Foehn?

By July 21 three mutually satisfactory nights transit observations had been obtained, as well as some latitude observations.

Several photographs were taken to connect the observatory with surrounding buildings.

TADOUSAC.

Last April Sir William Macgregor, Governor of Newfoundland, wrote to me expressing the desire to have some point (e.g. Chateau bay) in Labrador fixed in longitude, as there was no telegraphic longitude station on that coast. After discussing the matter with you, it was arranged that I should occupy Tadousac at the mouth of the

Saguenay, the accurate longitude of which was besides desired, while Sir William would occupy Chateau bay. The longitude of Chateau bay would not only serve as the initial or governing longitude for the Labrador coast, but would also assist in the determination of the position of the Canadian and United States (Lick observatory) eclipse expeditions.

Accordingly after completing the observations at Father Point I proceeded to Tadousac, via Rivière du Loup, where the necessary building material, lumber and cement, had to be obtained.

At Tadousac the Ontario and Richelieu Navigation Company kindly consented to the erection of the pier and observing hut on their premises to the rear of their hotel. The foundation of the pier was in firm sand, which is preferable to rock.

The telegraphic connection between Ottawa and Tadousac was via the Great North Western, through Montreal and Quebec, to Murray bay, where the government telegraph along the north shore of the St. Lawrence begins, and then to Tadousac, a distance of 461 miles, of which 1¼ miles are cable across the mouth of the Saguenay. There was a repeater at Montreal. On the Ottawa-Montreal section of 120 miles, there were 120 volts, and on the remaining section 180 volts.

From Tadousac to Château bay, opposite Belle Isle, is 958 miles; there are two cables on this section, the one of 12 miles between Bersimis and Pointe aux Outardes, and the other of 26 miles, between Pointe Paradis and Rivière Gadbout. The cables being so short, form directly a part of the land line system.

Mr. D. H. Keeley, general superintendent, had arranged for the use of the government line, and Mr. Edwin Pope, district superintendent, and also superintendent for the Great North Western, at Quebec, issued instructions to the operators along the line about the exchange of time signals.

On these 958 miles there are two automatic repeaters, one at Bersimis, 98 miles east of Tadousac, and another at Mutton bay, 611 miles east of Bersimis.

On August 1, Sir William Macgregor wired me his arrival with 6-inch transit and 6 box chronometers at Château bay. The government line is not in such good working conditions as one desires, the operators are more or less unskilled both in operating and in the adjustment of the telegraph instruments so that long delays occur and even complete failure, as happened on the nights of August 1 and 2.

On August 3 the first satisfactory exchange with Château bay was had, and another on the 5th. The following day Sir William left for Cartwright, in connection with the eclipse expedition. His time determinations at Château bay were confined to solar observations, as no stars were visible during his stay. After the eclipse he returned to Château bay on September 1, and had time exchanges directly with Ottawa (as I had left Tadousac), a distance of about 1,400 miles.

On August 8, I had the first time exchange, Tadousac-Ottawa, and a week later four mutually full nights of observations had been obtained, and the longitude of Tadousac determined.

A series of latitude observations by Talcott's method was also obtained.

A linear connection was made between the observing pier and the hotel.

The meridian through the centre of the pier passes one foot west of the flag-pole over the tower of the main or office entrance to the hotel, and the flag-pole is 211 feet south of the pier. It is 170 feet from the southeast corner of the hotel verandah to the pier, 109 feet along the meridian from the rear of the hotel to the pier, and 56 feet 5 inches from the northwest corner of the billiard room building to the pier.

Several photographs were taken showing the relative position of the observatory to surrounding objects, including also the lighthouse on the reef extending from the south side of the Saguenay into the St. Lawrence.

HARVARD.

As Harvard College observatory has been the zero or initial meridian of longitudes for the United States, it was deemed desirable that a direct connection should be

made between Harvard and Ottawa, especially as we were making a connection on the other side of the continent, Vancouver-Seattle, between the Canadian and United States longitude work. Under your instructions, I proceeded to Cambridge, Mass., last April, and there discussed the matter with the director, Prof. E. C. Pickering, who not only offered his hearty co-operation but suggested putting up a suitable transit building and pier on the observatory grounds for our purpose. The kind offer was readily accepted, and shortly afterwards the building, a neat 10 ft. x 12 ft. painted structure, having a cement pier 22 in. by 32 in., was ready.

The building has a tinned gable roof, and a shutter (wooden frame covered with painted canvas) on each side over the two-foot clear opening.

'The centre of the large dome' is the point on the Harvard observatory grounds to which the Coast and Geodetic Survey determinations of latitude and longitude have been referred. Between this point and my pier linear connection was made by Mr. W. P. Gerrish. The pier is north of the dome 135·94 ft.$=1''·34$, and west thereof 124·14 ft.$=1''.65 = 0·11$s. So that the geographical position of the pier based on the Harvard position of the dome is: Latitude 42° 22′ 48″·94, longitude 4h. 44m. 31·16s.

In the latter part of August I repaired to Boston for the Harvard-Ottawa longitude campaign.

After mounting the transit, it was discovered that the transit micrometer attachment was considerably deranged. The recording took place about 15 revolutions from the centre of the field. Having adjusted this, it was found that the ebonite ring was loose on the micrometer wheel, due to the flattening of the pinch washer. This too was satisfactorily repaired.

The clock or chronometer (Dent 48419) was placed in the basement of the Harvard main building, where is mounted also the Harvard standard sidereal clock. The temperature here, with one exception, kept within a range of 1° F. per day. A single Columbia dry cell was used for the chronometer and a single wire (150 feet) between the chronometer and my observatory, the other end being well grounded, the circuit was very satisfactory.

For the telegraphic exchange of time signals the Western Union and Great North Western telegraph companies kindly placed their lines at our disposal, and their service was highly efficient and satisfactory. The route was Ottawa to Montreal, 120 miles, 120 volts; and Montreal to Harvard (Boston), 394 miles, 180 volts; total distance 514 miles. There was a repeater at Montreal.

Unfavourable weather, rain and clouds, retarded materially the progress of the work.

As an especially strong connection was desired between the Canadian and United States initial meridians five mutually good nights of observation were taken and the work completed on September 21.

During my sojourn I embraced the opportunity to visit Blue Hill observatory, one of the foremost meteorological observatories in the world, and of which Mr. A. H. Rotch is director, owner and supporter, although Harvard College observatory publishes its annual reports and results. It is situate 635 feet above the sea, on the highest point on the immediate Atlantic coast between Maine and Florida. Its distinguishing work is the study of the upper regions of the atmosphere by means of kites. The kites are of the Hargrave (Clayton-Hargrave) pattern, 'dry-goods boxes,' and are an anomaly to the memory of one's boyhood, when one flew kites that looked like kites, which had such nice long gracefully moving tails. Of this appendage the scientific kite is devoid. The kite is a rectangular parallelepipedon, the edges being thin bamboo rods braced by thin wire. The surface is covered with 'percaline,' a closely woven light cotton fabric. To the kite is attached a meteorograph in small compass and containing all the necessary self-recording meteorological instruments. Piano wire takes the place of the boy's string, and is wound and unwound from a large reel operated by a two-horse-power engine. These kites have been flown to an altitude of over two miles. The height is determined by observing the angle of elevation with a theodolite and the

known length of wire reeled off. Heights have been determined too by direct triangulation or simultaneous observations from a fixed base line.

A new form of nephoscope was observed. It is a telescope pointing to the pole, and including within its field Polaris. In the focus of the telescope is placed a photographic film, and by an ingenious device the exposure is begun an hour after sunset and closed an hour before sunrise. If the sky is unobscured in the vicinity of the pole, Polaris will trace its path on the film, otherwise the trace or trail will be broken by intervening clouds. Automatically the film is shifted daily, and a week's record upon each film is obtained. The records are very sharp, the occurrence, duration and time of obscuration by clouds are readily obtained. Incidentally, flashes of lightning in the field of the instrument are well recorded. The complementary instrument to the above is the sunshine recorder.

Reference may be made to an apparatus installed at Blue Hill for recording minute quantities (drops of rain), quantities that could not be measured nor even detected by the ordinary rain-gauge. A mica plate covers a cylinder carrying a sheet of paper ruled with aniline ink into appropriate time divisions, the cylinder being driven by clock work. In the mica is a ⅜-inch hole. If the rain fall is confined to individual drops only, a drop falling through this hole will wet the paper and blot the ink on one or other of the time lines, and thereby record the fact that some rain fell.

While at Harvard, Mrs. Fleming discovered (August 31) a new star—Nova Aquilæ No. 2—in the constellation Aquila. A photograph of its spectrum, which the director showed me, shows the hydrogen lines $H\delta$, $H\gamma$ and $H\beta$ bright and broad, also faint traces of the bright bands 4472 and 4646. On August 18 the star had a magnitude of 6·5, which by August 26 had decreased to the 10th magnitude.

During my stay at Cambridge I familiarized myself as much as my unoccupied time permitted with the work of the observatory, and it may not be out of place to quote the words of Prof. Pickering with reference to the policy of the observatory. 'The policy of the astronomical observatory at Harvard College, since its establishment, has been the development of the physical side of astronomy. While much time and money have been spent on the determination of the positions and motions of the stars, the work has been mainly in determining their brightness, spectra, and other physical properties. In recent years, routine investigations on an extensive scale, each occupying many years, have constituted the principal part of the work. When practicable, every investigation is made to cover the entire sky, the northern stars being observed at Cambridge, and the southern at the station in Arequipa. An attempt is made to secure the most favourable condition for observation and to employ new and improved methods to compensate for the lack of instruments of the largest size.

'This work is greatly extended and facilitated by the collection of photographs mentioned above, and an endowment should be provided for utilizing it to the utmost. When any new object is discovered, we have here the only existing means of studying its past history for many years. As examples may be mentioned Nova Aurigæ, the planet Eros, and Comet *a*, 1904. The only evidence of the existence of these bodies before they were discovered was that contained in the Harvard photographs. The changes of all newly discovered variables, or other objects, can thus be traced back through the last fifteen years. Doubtless many objects of the greatest interest, but not yet discovered, might be found from these plates.

'The observatory now aims to cover a still wider field. Large sums of money have hitherto been given to astronomy, much of which, for lack of good advisers or of a technical knowledge of the subject by the donor, has been unwisely expended. There are, therefore, many large telescopes which are idle, observatories insufficiently endowed, and skilful astronomers whose appliances for research are entirely inadequate.

'It is the object of this observatory to supply these needs, by securing a fund the income of which could be used for aiding astronomers in all parts of the world. Such a fund, conscientiously administered, either here or elsewhere, should give far greater scientific returns than would be possible if expended at a single station. It would aid the work, not of a single astronomer, but of a selected number of the most eminent

specialists in the world, and by co-operation would enable investigations, too large to be undertaken at a single observatory, to be conducted successfully. The sympathetic interest of experts, ready and able to make substantial grants, would greatly aid the work of young or isolated astronomers of ability.'

After completion of the Harvard observations and return to Ottawa, personal equation observations were made between Mr. R. M. Stewart and myself. During the season he observed at Ottawa with Cooke No. 1 transit, which is as yet not provided with the transit micrometer. A transit shed and pier were erected 20 feet 4 inches due south of the temporary one occupied by Mr. Stewart to the east of the main observatory. In the spring, before leaving for British Columbia, Mr. F. A. McDiarmid and I observed for personal equation respectively with No. 2 and No. 3 Cooke, each of them being provided with the transit micrometer. As anticipated, the differential personal equation, with the transit micrometer became practically a negligible quantity. About the same time Mr. McDiarmid and Mr. Stewart observed for personal equation, using respectively Cooke No. 2 and No. 1. The resulting value gave the personal equation of Mr. Stewart, who used the transit key while observing transits over the 11 threads of the diaphragm. It was hence really not necessary for me to observe to obtain the personal equation of Mr. Stewart, however, it was thought more satisfactory to do so, adding thereby to the weight of the differential longitude Harvard-Ottawa.

Four independent time determinations were made between us in three nights. The same clock Howard was used, the current being divided between the two relays of the observing huts. The clock is in the time room of the observatory and has a rate (losing) of less than a second a day. Each time determination consisted of 12 stars, six observed in position clamp east, and six in clamp west. One of the stars in each position of the instrument was a polar. To eliminate the error of star places the same stars were observed each night by the two observers. None of the observations have as yet been reduced.

PENDULUM APPARATUS.

In the spring of 1902, I proceeded to Washington to receive the half-seconds pendulum apparatus that had been constructed by Saegmuller under the supervision of the United States Coast and Geodetic Survey, and also to observe therewith on the Coast and Geodetic Survey pendulum pier in the basement of the survey building. This pier had been occupied some years before by Commandant Defforges with a seconds-pendulum and also by Mr. G. R. Putnam with the half-seconds pendulum before and after observing with the same apparatus at London, Paris and Berlin, standardizing international observations. As the half-seconds pendulum apparatus gives not absolute but only relative values for gravity, it was desirable that observations with our apparatus should be made at a station where the absolute value of '*g*' was known, so that future relative values when obtained, might be converted into absolute ones, becoming thereby available with foreign values for the further study of the figure of the earth, and more particularly its deviation from the one based on mathematical considerations. For this reason observations were made at Washington, and also to familiarize one's self with this form of apparatus under the supervision of an expert observer, Mr. Edwin Smith.

This apparatus is the outcome of the want felt for a portable apparatus, insuring accuracy, rapidity of observation and convenience. Hitherto the cost involved in using the reversible seconds pendulum for the determination of gravity at a station was large, and the time required was considerable, so that comparatively few stations could be occupied in a season.

In 1891, Professor T. C. Mendenhall, at the time superintendent of the United States Coast and Geodetic Survey, had constructed a half-seconds pendulum apparatus, which has been successfully used ever since. The Canadian apparatus is modelled after the above. Its characteristic features are, three invariable non-reversible pendulums; an air-tight receiver in which the atmospheric pressure is under control; a flash appar-

atus for noting coincidences between the oscillations of the pendulums and the second breaks of a sidereal box chronometer; and a dummy or temperature pendulum.

The accuracy arrived at in pendulum observations for the measurement of relative force of gravity is to determine the period of oscillation, and also the variable conditions that affect that period. To attain the latter the air-tight compartment adds in a high degree.

Pendulums.—Three pendulums (two thereof, a, b, shown in fig. 3), each designated by a number, 1, 2, 3, constitute a set, the advantage of this number being that, if discrepancies appear in the results the one at fault may be detected. The pendulums are made of an alloy of aluminum 10 per cent and copper 90 per cent, a composition which experiment proved to have a very high resistance to corrosion; they are highly polished, but not lacquered. Each weighs approximately 1,200 grammes, and is about 248 millimetres in length from the centre of the bob to the agate plane. The lengths of the three pendulums differ slightly, being made intentionally so. The stem and bob are designed so as to offer little resistance to the air when in motion. The bob is solid, and is 9 centimetres in diameter and 4·5 centimetres thick at the centre. Its form is lenticular. The stem of the pendulum is rectangular in section, 4 by 14 millimetres, with rounded edges, and is rigidly fastened to the head and the bob. The pendulums have an agate plane, *c*, set in the head which rests on the agate knife-edge, *d*, on which they are swung. This so-called knife-edge is formed by carefully ground planes meeting at an angle of 130°, thus insuring greater permanency than could be expected with a sharper edge. For invariability in the length of the pendulum it is preferable to have the knife-edge as support instead of on the pendulum itself. The knife-edge is set in a solid metal plate, *e*, which is secured by a screw to the shelf in the pendulum case, or receiver, *f*, fig. 4. As a check in case of injury, there are two knife-edges with the apparatus marked I. and II., each in its own plate, either of which may be set in the case. The advantage in using several distinct knife-edges as well as distinct pendulums being that by the relation between the independent results thus obtained, a continual check on the constancy of the instruments is furnished.

A small rectangular mirror, *g*, is set in each side of the pendulum head. These require very careful adjustment, so that from any of the pendulums with either face front, the image of the slit in the flash apparatus, described later, will be reflected into the same portion of the field of the observing telescope, when the latter is properly placed, and in line with the image of the fixed similar mirror on the plate carrying the knife-edge.

The pendulum is carried to and from the box in which it is kept, from and to the receiver, by a double-jointed handle, *h*, which has leather-lined hooks fitting under pivots on each side of the head. It is, therefore, never necessary for the hand to come in contact with the pendulum. When placed in the receiver the pendulum is first suspended upon two pivots carried on the end of a lever, which pivots fit into corresponding sockets in portions of the head projecting at each end over and beyond the agate plane. This lever is moved by a large milled-head screw, *i*, on the outside of the receiver so that the pendulum may be gently lowered and raised without injury to the knife-edge, which could not so safely or readily be done directly by hand. A spring, *k*, holds the lever against the end of the screw, and stops limit its action.

The temperature of the swinging pendulum is ascertained by means of a dummy, *l*, similar to the others in material and dimensions, save that it has no mirrors, and is supported within the receiver that it cannot oscillate. It has mounted on its stem a thermometer, *m*, whose bulb is buried in the stem near the bob, and packed with the alloy metal filings, the endeavour being in this way to obtain as near as possible the actual temperature of the swinging pendulum.

The Receiver.—The body of the receiver, *f*, is a heavy brass casting, with walls 7 millimeters thick, and of inside dimensions 17 centimetres square at the top, 21 by 28 cm. at bottom, and 38 cm. high. The cover makes an air-tight joint when a little tallow is applied to the contact surfaces. A portion of the main casting forms a solid shelf,

but having openings in it through which the pendulum, dummy, and lever hang. This shelf carries on one side a plate on which the dummy pendulum is supported, and on the other the plate carrying the knife-edge on which the pendulum swings. This latter plate is supported on three points and firmly screwed to the shelf. To it is attached the adjustable fixed mirror, *n*, already referred to, and is so adjusted that the images of the slit, as seen in the observing telescope, *o*, reflected from this mirror, and from that on the pendulums, when hanging freely at rest, will appear in the same horizontal line, and slightly overlap each other.

There is a scale below the pendulum, and a small telescope mounted on the side (on the opposite face of fig. 4) of the receiver for reading the arc of oscillation. The receiver is supported by three large foot screws, *p*, resting on heavy circular foot plates, one of which has a spherical hole, one is flat, and the other has a V-shaped cut for the reception of the foot screws. These foot plates are cemented to the supporting pier. By proper disposition of the direction of the V, there is no binding of the foot screws due to change of temperature of the case. The case or receiver is levelled in the plane of oscillation by the pendulum itself as shown by the reading of the tip of the pendulum on the scale beneath. In the transverse plane it is levelled by a small level, *r*, mounted in a short pendulum which may be reversed on the knife-edge. On the sides of the case are two levels, *s*, *t*, transverse to each other, for assisting in levelling the case. Within the receiver there is a short arm for setting the pendulum in motion. The arm is covered with leather at the point of contact, and is worked from the outside. Adjustable screws limit the motion of this handle, so that it may be set for any desired amplitude of oscillation, and the same amplitude used for succeeding swings. A mercury manometer is hung within the receiver, and by means of a portable air pump, *u*, the air is exhausted through stop cocks on the side of the case to about 55 mm. Three windows, *j*, *v*, *w*, (*w* not shown) are provided in the case for observing respectively the mirrors, arc scale, dummy thermometer and manometer. The box to the right, fig. 4, is for the plate, *e*, with agate knife-edge, *d*.

Flash Apparatus.—The flash apparatus consists of a light metal box, *x*, mounted on a brass stand having both vertical and azimuthal movements and clamps, and carries above it an ordinary observing telescope, *o*, which may be focussed for objects within a few feet. The object of the flash apparatus is to observe coincidences between the swinging pendulum and the chronometer used for determining the period or time of oscillation of the pendulum, which in turn depends upon the time determination made by means of the chronometer, *i.e.*, the time determinations made by observing transits of stars with the chronometer serve as a scale with which to measure the period of the pendulum. This box contains an electro-magnet, whose coils are connected with the chronometer circuit, and whose armature carries an arm which moves two shutters; by an ingenious device a flash of light is emitted from the box only when the circuit is broken. The light for the flash is furnished by a small oil lamp, *y*, attached to one side of the box, the light from which is concentrated by a lens on to the slit after being reflected by a mirror in the interior of the box set at an angle of 45°. The chronometer is made to break circuit at every even second, omitting the 58th for identification of minute. It is the illumined image of the slit that falls on both the fixed mirror and the mirror on the pendulum; and these two images are observed by means of the telescope.

When the pendulum is swinging, the image as reflected from the pendulum mirror will change its position relatively to that of the fixed mirror as seen in the field of the telescope, because of the fact that the pendulum makes a double oscillation in a little more than a sidereal second, and hence will be found slightly behind its former position at the end of each break when the flash is thrown. The moving image will, therefore, appear to travel up and down across the field of the telescope by successive jumps, wholly disappearing from the field to return again with apparent retrograde motion. Coincidences are observed by noting the time when the two images are in the same horizontal line. It is evident that in the interval between two occurrences of this phenomenon the pendulum has made one less than twice as many oscillations as the

chronometer has beat seconds, and that in an interval of time between the first and last of a number of coincidences, the number of oscillations of the pendulum will be twice the number of seconds (s) less the number of coincidence intervals (n), so that the time of a single oscillation is readily derived from the relation $P = \frac{s}{2s-n}$. The elegance of the coincidence method lies in the fact that a small error in noting the time of coincidence has little effect on P.

Use of Apparatus.—One of the principal advantages of this apparatus is the ease with which it may be used, and the few inexpensive preparations necessary for its installation. For the best work a well-founded brick or cement pier upon which the receiver may rest is essential. The flash apparatus may be placed upon a table near the pier. If the apparatus can be placed in a room of nearly constant temperature the results will be more uniform, but if sufficient time is allowed before swinging for the pendulum to come to the temperature of its chamber, as represented by the thermometer in the dummy, this is not essential. The correction for temperature may be so well known that results obtained at temperatures differing widely will be in close accord when this correction is applied. The room should be somewhat dark in order that the flash may be easily seen in the field of the telescope.

The routine of observing is as follows: We begin by making a suitable number of transit observations to determine the error of the chronometer, which will subsequently be used for the flash apparatus for determining the period of the pendulum. We next place one of the pendulums, face direct on the pivots, into the case, the dummy and manometer having already been placed therein. The lid, with its thin coating of a mixture of sperm oil and sheep's tallow, is then put on. Next, by means of the air pump, the air is exhausted to a pressure of about 55 mm., and the stop cocks closed. The pendulum is now gently lowered by means of the milled-head screw, already described, and the pendulum made to oscillate by means of the handle moving the arm which deflects the bob. Immediately thereafter the scale is read showing the amplitude of oscillation, also the manometer and thermometer of the dummy. It is customary to read an outside thermometer.

The telescope having been adjusted beforehand so that the image of the fixed mirror falls centrally in the field and that of the pendulum beside it, the observations for coincidence are begun. Presently one will see the image of the pendulum mirror approaching (or receding) the fixed image. The image increases in brightness, and each break will see it a little nearer the fixed image until coincidence takes place, when the time thereof is noted. This is done by picking up the beat of the chronometer, which one hears, every two seconds with our chronometers, by the click of the shutter of the flash apparatus. It is customary to count by half-seconds, *i.e.,* the flashes would come at multiples of four. If coincidence does not take place just at a flash, one estimates the position of the image of the pendulum image at the flash preceding and succeeding coincidence and records the coincidence accordingly. This coincidence, let us suppose, to be on the downward motion of the moving image, we record this then as D, with its corresponding time, after an interval of about two minutes, depending upon the latitude, the image will be seen to be approaching from the opposite direction as before until similarly coincidence takes place, and is recorded as U (up) with the time. The following two coincidences are similarly noted, which then suffice for this chronometer.

It is customary to use two chronometers and to have them suitably connected with switches for intercomparison, and for putting either on the flash apparatus, as well as on the chronograph used for the determination of time of star transits.

It is generally possible to interpolate the coincidences of the second chronometer between those of the first, by moving the switch from one to the other. In order to pick up the beat, that is, the proper second of each chronometer, as there is generally not time to wait for the electric interval indicating the full minute, it is customary to have a pocket or other box chronometer beside one, and whose relation in second beats to the two observing chronometers is known, so that by means of the former the count-

ing for the seconds of the latter can readily be picked up. With the second chronometer then coincidences, two D's and two U's, are observed as with the first.

This finishes then the first stage of the observations for swing 1. Between 7 and 8 hours afterwards, these observations are repeated together with reading of temperature, pressure and arc,—which complete, then a determination for the period of the pendulum in position D, knife-edge I.

The stop cock, *z*, is now opened, air admitted into the chamber so that the lid or cap may be removed, however, first raising the pendulum by means of the milled-head screw off the knife-edge on the pivots. After removal of the lid, the pendulum is reversed, R, by means of the handle, let down on the pivots, the lid replaced and the air again exhausted to about 55 mm., the pendulum lowered on to the knife-edge, made to vibrate as before, readings taken of the dummy thermometer, manometer, and amplitude arc, and coincidences noted by the two chronometers. After a lapse of something over 7 hours, the observations are repeated and the second set for period of oscillation obtained, in this case for position R, knife-edge I.

We next observe with pendulum 2 and knife-edge II a set D, and other set R. This is followed by a set D, and set R, with pendulum 3, giving for the three pendulums their twelve determinations of periods, two for each pendulum for each chronometer.

The whole of the observations are then repeated in the inverse order, giving twelve swings each of somewhat less than 8 hours duration.

These then are grouped for each pendulum.

From the two chronometers we obtain a mean value of the period for each pendulum in each position, that is, for each pendulum there will be four mean values, two for position D, and two for position R. The mean of these four means gives the mean period for the respective pendulum, and the mean of the three pendulums the desired period of the pendulums.

While the pendulum observations are in progress it is essential that time observations be taken too for determining the error and rate of the chronometers used for noting coincidences, and especially is it necessary that time observations be obtained at the completion of the pendulum observations, for such constitute the end of our time measuring scale with which the periods are measured.

It may be here mentioned that with careful observations and under favourable conditions the periods determined for an individual pendulum will agree within the seventh place of decimals of a second, that is, will agree within the units of the ten millionths part of a second.

REDUCTION OF OBSERVATIONS.

From the observations we obtain the duration of each swing, counting from a U to a U, and from the corresponding D to D. From two successive U's and D's we obtain the approximate interval in seconds between two coincidences, remembering that a D or U coincidence falls respectively between two U's or D's. Dividing the number of seconds in this interval into the duration of swing, the number of coincidences is obtained. Although the quotient is not exact, it must be a whole number, and there is no question what the whole number is, as the quotient readily indicates that. Then reversing the operation, the whole number of coincidences is divided into the duration of swing, or total number of seconds to obtain the average number of seconds in one interval. The uncorrected period is then obtained from the relation

$$P = \frac{s}{2\,s - n} = .500 + \frac{n}{4\,s - 2\,n}.$$

In order to make the periods comparable with those obtained with the same pendulums at other times and stations, it is necessary to reduce them to certain standard conditions. These conditions, which are arbitrarily adopted are: arc infinitely small, temperature 15° C, pressure 60 mm. of mercury at O° C, true sidereal time, and inflexible support.

Arc correction.—The correction to reduce the time of oscillation to what it would be were the pendulum swinging in an infinitely small arc is obtained by an adaptation of Borda's formula, as follows:—

$$\text{Arc correction} = -\frac{\text{PM Sin}(\varphi + \varphi')\ \text{Sin}(\varphi - \varphi')}{32\ (\log \text{Sin}\ \varphi - \log \text{Sin}\ \varphi')}$$

When P is the period of the pendulum in seconds, M is modulus of the common logarithmic system, φ and φ' are the initial and final semi-arcs respectively.

Temperature Correction.—The co-efficient necessary for this correction was determined experimentally at Washington with pendulums of the same material and construction as those of our office, by swinging pendulums at temperatures, differing about 20° C, and obtaining the periods at the different temperatures.

From these experiments the formula for correction for temperature was derived:—

Temperature Correction $= + \cdot 00000418\ (15° - T°)$.

T being the temperature in degrees Centigrade.

Pressure Correction.—In the original formula of Mendenhall, the standard pressure was taken at 500 millimetres, but for later observations the standard has been made 60 millimetres, and the following formula from observations by G. R. Putnam in 1894, gives the

$$\text{Pressure correction} = + \cdot 000000101 \left[60 - \frac{\text{Pr}}{1 + \cdot 00367\ T°} \right]$$

Where Pr is the mean of the observed pressures at beginning and end of swing, and T° the mean temperature of the pendulum during the swing. The expression $\frac{\text{Pr}}{1 + \cdot 00367\ T°}$ is simply a reduction of the air pressure to a temperature of O° Centigrade.

Rate Correction.—The periods are reduced to sidereal time by correcting for the rate of the chronometer. If the chronometer is gaining, then as a time measuring scale its seconds are too short, and the deduced period of the pendulum will be too long. Hence for a chronometer gaining, the correction is subtractive; and additive when losing. The reciprocal of the number, 86,400, seconds in a day is ·000011574, hence the

Rate correction $= \cdot 000011574$ R P, where P is the period and R the daily rate on sidereal time of the chronometer.

Flexure Correction.—The effect of flexure upon the period of the pendulum was determined experimentally at Washington for this form of pendulum apparatus, by placing it successively on supports—piers, posts and wooden framework—and finding the period for each support. By means of a weight, q, 1·5 kilogrammes, the force thereof applied horizontally in the plane of oscillation, the displacement of the knife-edge in microns is obtained. From these determinations the following formula is derived:

Flexure correction $= - \cdot 00000065$ D, where D is the observed displacement of the knife-edge in microns.

Applying the above four corrections the periods of the pendulums are obtained, and from them, g, for each station. In order, however, to compare them with each other and with other values of g by the relationship of the empirical formula, $g = 978 \cdot 066\ (1 + \cdot 005243\ \text{Sin}^2 \varphi)$ (Putnam), where φ is the latitude, reduction to sea-level must be made. The reduction to sea-level is always positive and is of magnitude $2\frac{H}{r}g$, H being the height of the station above sea-level, and r, the mean radius of the earth. This term is independent of the matter lying between the station and sea-

level. This matter increases gravity, and the correction therefor $\frac{3H}{r}\frac{\delta}{\Delta}$, in which δ is the density of the matter above sea-level and Δ the mean density of the earth, is necessarily negative.

The reduction to sea-level then takes the form, known as Bouguer's formula $dg = +\frac{2gH}{r}\left(1-\frac{3\delta}{4\Delta}\right)$, on the supposition that the station is situate on an indefinitely extended horizontal plain.

Any deviation from the latter condition by mountain masses above the station or valleys beneath the same will decrease the gravity at the station and hence a correction, the 'topographical' correction, giving a third term to the above expression, will have a positive sign. To evaluate this term contour maps of the country surrounding the station are necessary, also the density of the matter.

OTTAWA.

The pendulum observations were made in the basement of the Supreme Court building on the east side of Bank street, and within the parliament grounds. The place was well adapted, as there is very little traffic on the streets in the neighbourhood. In this basement (same compartment) was installed the Harvard sidereal clock, which was used for years for all time observations made at the old small observatory (transit house) on the north side of Cliff street, between the properties of Mr. R. J. Devlin and Mr. G. Holbrook, and on the immediate precipice overlooking the Ottawa river. For the pendulum observations, part of the floor in this part of the basement was removed, a cement pier, 2 feet square, was built on the limestone rock in situ, which immediately underlies the floor. The pier was enclosed within a double-walled room 8 feet square, to insure a fairly uniform temperature, and to protect the pendulum apparatus from currents of air. The flash apparatus was placed on a table immediately contiguous to the outer wooden wall of the pendulum room, and the coincidence observations were made through a rectangular aperture 4 inches by 6 inches, in the wall; when not observing this aperture was closed.

The two time-pieces that were employed for noting the coincidences were the Howard sidereal clock and Dent sidereal chronometer No. 48419, both breaking every two seconds. The Howard clock was used for the time determinations, and comparisons between the clock and chronometer were made at every swing of the pendulum. The chronometer was kept in the pendulum room. The comparisons were made on a large Favarger chronograph in the basement, while the transit observations were recorded on the chronograph in the transit house.

The clock, chronometer and flash apparatus were connected by four small two-point switches on the table, and at the immediate command of the observer. For taking the readings of the thermometer, manometer and arc an electric light on a cord was turned on.

The top of the guard stone at the west side of the entrance to the parliament grounds, near the Supreme Court building, is 120·82 feet above the city datum. The city datum is 120·00 feet above mean tide level. These measurements are from the records of the city engineer. The height of the pendulum based on above data is therefore 73 metres above mean tide level. In the reduction for 'sea level' for the value of gravity at Ottawa, the mean density of the earth is taken at 5·576, and the surface density of the earth at 2·56, being about that of limestone.

In the Tables I. and II. are given the results of the swings at Washington and Ottawa. For comparison the results are grouped by pendulums and not chronologically.

The ratio of gravity at two places is readily obtained from the fundamental formula of the simple pendulum, $P = \pi\sqrt{\frac{l}{g}}$ where P is the period, l the length of the corresponding pendulum, and g the force of gravity.

For the invariable pendulum we have then $P_o^2 : P_w^2 :: g_w : g_o$ or $g_o = \frac{P_w^2}{P_o^2} g_w$.

The observed value of g, at Washington is taken as 980.098 (not reduced to sea level), as this value has been used by the Coast and Geodetic Survey for the deduction of all other values of g in the United States. Commandant Defforges obtained the value, relatively to Paris, 980·167,* and based on the value of g at Potsdam, the observations of Mr. G. R. Putnam at Potsdam and Washington with the same pendulums gave for Washington $g = 980.111$,† agreeing pretty well with the tentative value 980:098.

From the subjoined Table III. the interagreement between the ratios of the periods of the individual pendulums at Washington and Ottawa can be seen in the deduced value of g for Ottawa, obtained for each pendulum from the above formula.

TABLE III.

Pendulum.	Period Washington.	Period Ottawa.	Deduced gravity Ottawa.	Difference from mean 3 decimal place.
I.	·5014337	·5013073	980·592	+1
II.	·50157[illegible]5	·5014531	980·592	+1
III.	·5015530	·5014259	980 594	−1

Clairaut's Theorem.—This is generally expressed in the form $\frac{g^1 - g}{g} = \frac{5}{2} m - e$, in which g^1 and g are respectively the force of gravity at the pole and equator, m the ratio of the centrifugal force at the equator to gravity, and e the ellipticity of the meridian.

Clairaut also proved that the increase of gravity towards the poles is as the square of the sine of the latitude: $g_\varphi = g \left\{ 1 + (\frac{5}{2}m - e) \operatorname{Sin}^2 \varphi \right\}$ for sea-level.

The evaluation of g_φ is dependent upon the values assigned for g, m and e, for none of which have as yet absolute values been obtained. This is one of the reasons why, in making comparison between the observed gravity and the theoretical values 'anomalies' of different magnitude and also of different sign are found. The other reason is in the uncertainty of the 'reduction to sea-level.'

In Appendix 1, Report Coast and Geodetic Survey, 1894, Mr. G. R. Putnam discusses the relative measurements of gravity at twenty-six stations in the United States obtained by means of the half-seconds pendulums. He says: 'So as to be able to study the results more intelligently, the values at sea-level have been compared with those computed by an assumed theoretical formula $g = 978{\cdot}066\ (1 + {\cdot}005243 \sin^2 \varphi)$, which is based on Clairaut's theorem, Clarke's figure of the earth, and the assumption that gravity is normal on the eastern coast of the United States.'

As Washington is the fundamental station for referring the Canadian values of gravity, the above formula has been adopted in the reduction.

For comparison two other well known formulæ may be given:—

Helmert (Höhere Geodäsie, Vol. II., p. 85) gives

$$g = 978{\cdot}00\ (1 + {\cdot}005310 \sin^2 \varphi)$$

and by Harkness (Smithsonian Tables, 1897)

$$g = 980{\cdot}60\ (1 - {\cdot}002662 \cos \varphi)$$

which reduces to

$$g = 977{\cdot}985\ (1 + {\cdot}005338 \sin^2 \varphi).$$

* App. 1 C. & G. S. Report, 1894. † App. 5 C. & G. S. Report, 1901.

TABLE

PENDULUM OBSERVATIONS

STATION—WASHINGTON, D.C.

Date.		Swing Number.	Pendulum.	Position.	Knife-edge.	Coincidence Interval. Chronometer—Negus. No. 1828.	Coincidence Interval. Chronometer—Negus. No. 1836.	Arc. Initial.	Arc. Final.	Temperature.	Pressure.	Period Un… Chronome… No. 1828.
1902.						s	s	′	′	C. °	m.m.	s
May	21	1	1	D	I.	168·295	171·464	51	21	20·65	54·05	·5014899
	24	10	1	D	I.	168·566	170·887	56	20	21·30	60·45	·5014875
	22	2	1	R	I.	168·434	171·554	65	23	20·20	53·40	·5014887
	24	9	1	R	I.	168·322	170·824	59	22	21·10	61·35	·5014897
	22	3	2	D	II.	153·664	155·957	60	22	20·05	57·30	·5016322
	25	11	2	D	II	153·108	155·114	59	21	21·62	58·40	·5016382
	22	4	2	R	II.	153·869	156·160	61	23	20·10	54·85	·5016301
	24	8	2	R	II.	153·594	155·802	58	23	20·75	59·10	·5016330
	23	5	3	D	II.	156·232	158·651	59	22	20·10	56·55	·5016053
	25	12	3	D	II.	155·633	157·758	57	17	21·82	59·25	·5016115
	23	6	3	R	II.	156.121	158·540	61	22	20·30	57·90	·5016065
	23	7	3	R	II.	156·145	158·474	59	22	20·60	58·00	5016062

TABLE

PENDULUM OBSERVATIONS

STATION—OTTAWA.

Date.		Swing Number.	Pendulum.	Position.	Knife-edge.	Coincidence Interval. Chronometer. No. Howard Clock.	Coincidence Interval. Chronometer. No. 48419 Dent.	Arc. Initial.	Arc. Final.	Temperature.	Pressure.	Period Un… Chrono… No. Howard Clock.
1902.						s	s	′	′	C. °	m.m.	s
Aug.	6	1	1	D	I.	187·423	185·082	58	19	19·73	38·2	·5013374
	10	12	1	D	I.	187·903	185·021	57	17	18·55	43·8	·5013340
	7	2	1	R	I.	187·137	184·773	65	17	19·60	44·3	·5013395
	10	11	1	R	I.	187·846	185·678	59	15	18·60	42·6	·5013344
	8	6	2	D	II.	169·014	166·673	95	27	19·10	44·9	·5014836
	9	7	2	D	II.	169·169	167·194	71	15	19·05	47·0	5014822
	9	5	2	R	II.	169·253	167·447	66	16	19·23	45·0	5014815
	9	8	2	R	II.	169·539	167·651	65	15	18·95	44·5	5014789
„	7	3	3	D	II.	171·955	169·723	59	15	19·65	44·5	·5014581
„	10	10	3	D	II.	172·753	170·816	59	14	18·70	45·3	·5014514
	8	4	3	R	II.	171·994	170·128	66	15	19·35	45·9	·5014578
	9	9	3	R	II.	172·740	170·580	57	14	18·80	42·9	·5014515

No I..

AND REDUCTIONS.

OBSERVERS—Otto J. Klotz and Edwin Smith.

CORRECTED.	CORRECTIONS (7th DECIMAL PLACE).						PERIOD CORRECTED.		
ter—Negus.				Rate.			Chronometer.		
No. 1836.	Arc.	Temp.	Pressure.	1828.	1836.	Flexure.	No. 1828.	No. 1836.	Mean.
s							s	s	s
·5014623	—8	—236	+10	—320	—46	—5	·5014340	·5014338	·5014339
·5014673	—9	—264	+4	—287	—67	—5	·5014314	·5014332	·5014323
·5014615	—12	—218	+10	—316	—48	—5	·5014346	·5014342	5014344
·5014678	—10	—255	+3	—290	—65	—5	5014340	·5014346	·5014343
·5016082	—10	—211	+7	—312	—51	—5	·5015791	·5015812	·5015802
·5016169	—10	—277	+6	—283	—70	—5	·5015813	·5015813	·5015813
·5016061	—11	—213	+9	—309	—53	—5	·5015772	·5015788	·5015780
·5016098	—10	—241	+5	—294	—62	—5	·5015785	·5015785	·5015758
·5015808	—10	—213	+7	—305	—55	—5	.5015527	5015532	·5015530
·5015897	—8	—285	+5	—279	—72	—5	·5015543	·5015532	·5015537
·5015819	—10	—222	+6	—301	—58	—5	·5015533	·5015530	·5015531
·5015825	—10	—234	+6	—298	—60	—5	5015521	·5015522	·5015521
Mean..							·5015219	·5015223	·5015221

No. II.

AND REDUCTIONS.

OBSERVER—OTTO J. KLOTZ.

CORRECTED.	CORRECTIONS (7th DECIMAL PLACE).						PERIOD CORRECTED.		
meter.				Rate.			Chronometer.		
No. 48419 Dent.	Arc.	Temp.	Pressure.	Clock.	48419.	Flexure.	No. Howard Clock.	No. 48419 Dent.	Mean.
s							s	s	s
·5013544	—9	—198	+22	—121	—280	—5	·5013063	·5013074	·5013069
5013549	—8	—149	+16	—128	—332	—5	·5013066	·5013071	·5013069
·5013567	—10	—193	+16	—119	—297	—5	·5013084	·5013078	·5013081
·5013501	—8	—151	+18	—124	—284	—5	5013074	·5013071	·5013073
·5015045	—22	—172	+15	—112	—325	—5	5014540	·5014536	·5014538
5014998	—10	—169	+13	—110	—284	—5	·5014541	·5014543	·5014542
·5014975	—10	—177	+15	—113	—269	—5	·5014525	·5014529	·5014527
·5014957	—9	—165	+16	—111	—274	—5	·5014515	·5014520	·5014518
·5014773	—9	—195	+16	—118	—310	—5	·5014270	·5014270	·5014270
·5014679	—8	—155	+15	—120	—279	—5	·5014241	·5014247	·5014244
·5014738	—9	—182	+14	—116	—276	—5	·5014280	·5014280	·5014280
·5014699	—7	—159	+17	—116	—307	—5	·5014245	·5014238	·5014242
Mean							5013954	·5013955	·5013954

By either of the last two the value of g for Washington becomes 980·047, while by the first it is 980·087, a difference of 40 in the third place of decimal.

The theoretical value (sea-level) for Ottawa, =45° 25′ 23″, is 980·668 by the first formula.

We have then for final values:—

Station.	Latitude.	Computed g.	Observed g.	Reductions to sea-level.	Observed corrected g.	Anomaly O-C.
Washington......	38° 53′ 13″	980·087	980·098	·002	980·100	−13
Ottawa	45° 25′ 23″	980·668	980·593	·015	980·608	−60

From this it appears that there is an excess in the force of gravity of Washington of ·013 dynes and a defect at Ottawa of ·060 dynes.

The defect at Ottawa is not surprising when one considers that the station is on the escarpment of the Ottawa river, with its wide valley running in an easterly-westerly direction, and extending far in both directions.

It may be stated that had the reductions for ‘computed g’ been made by either of the other two formulæ the anomaly for both of the above stations would have been increased algebraically, but the defect at Ottawa would nevertheless persist.

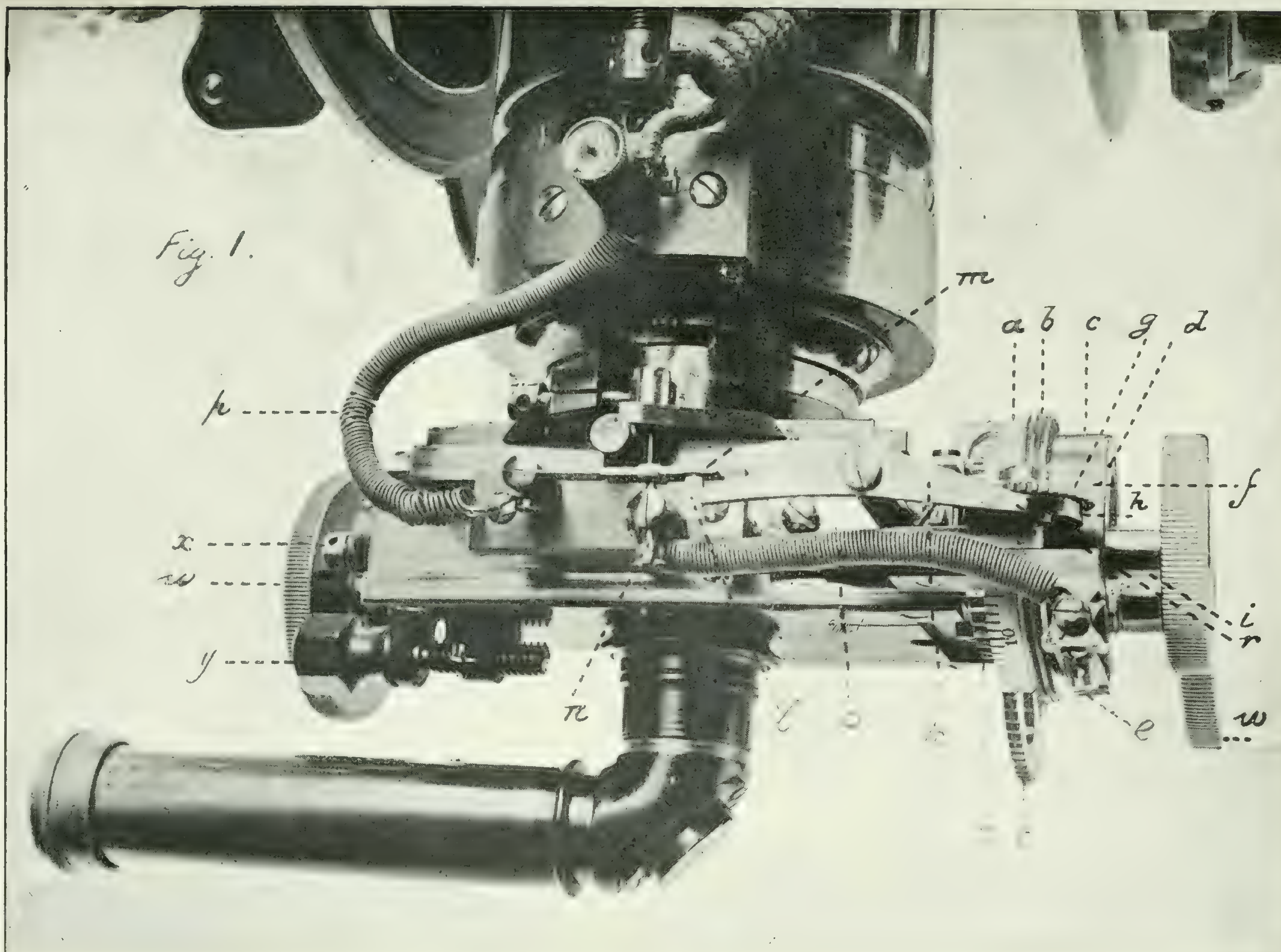

Fig. 1.—Transit Micrometer.

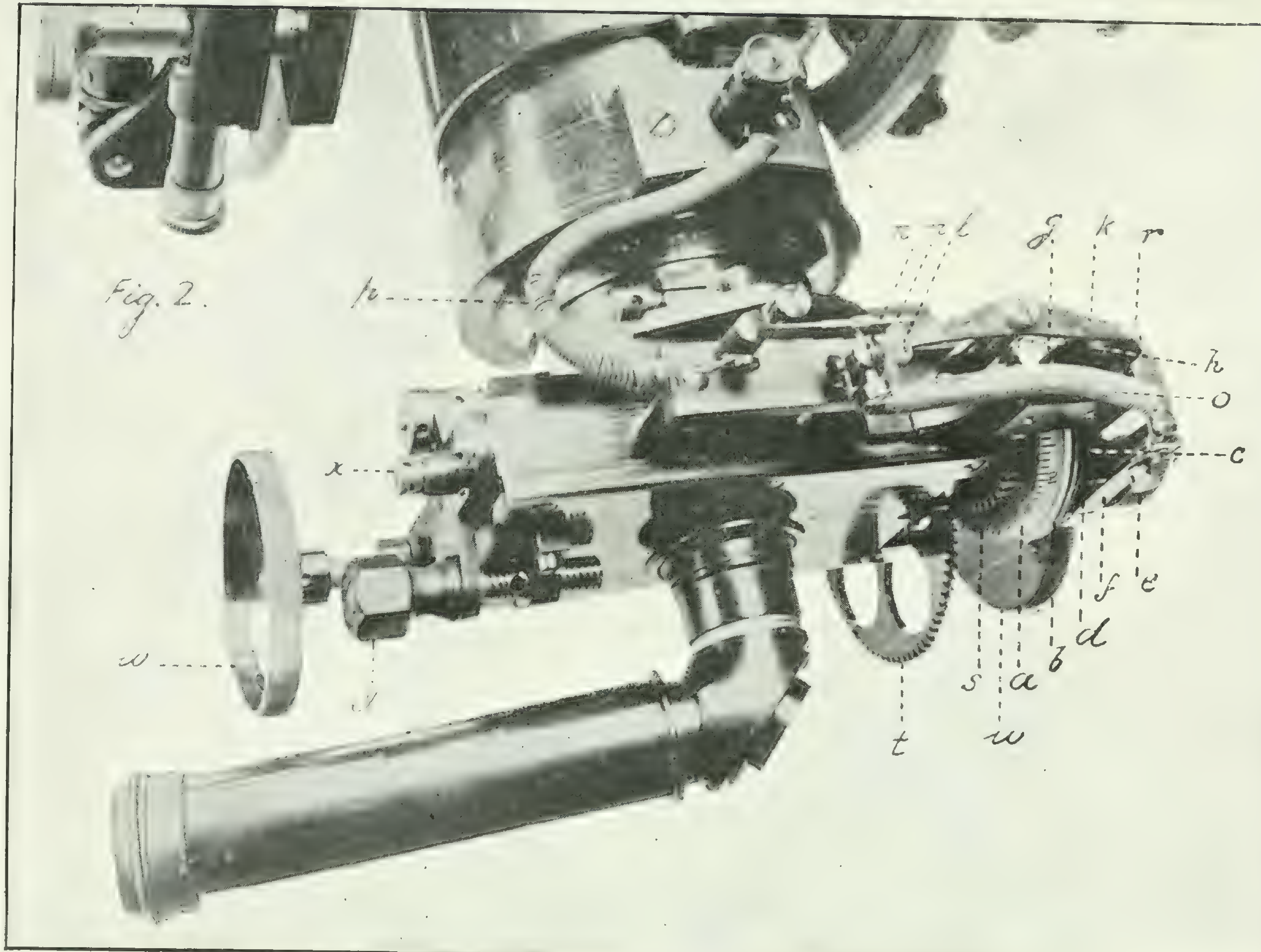

Fig. 2.—Transit Micrometer.

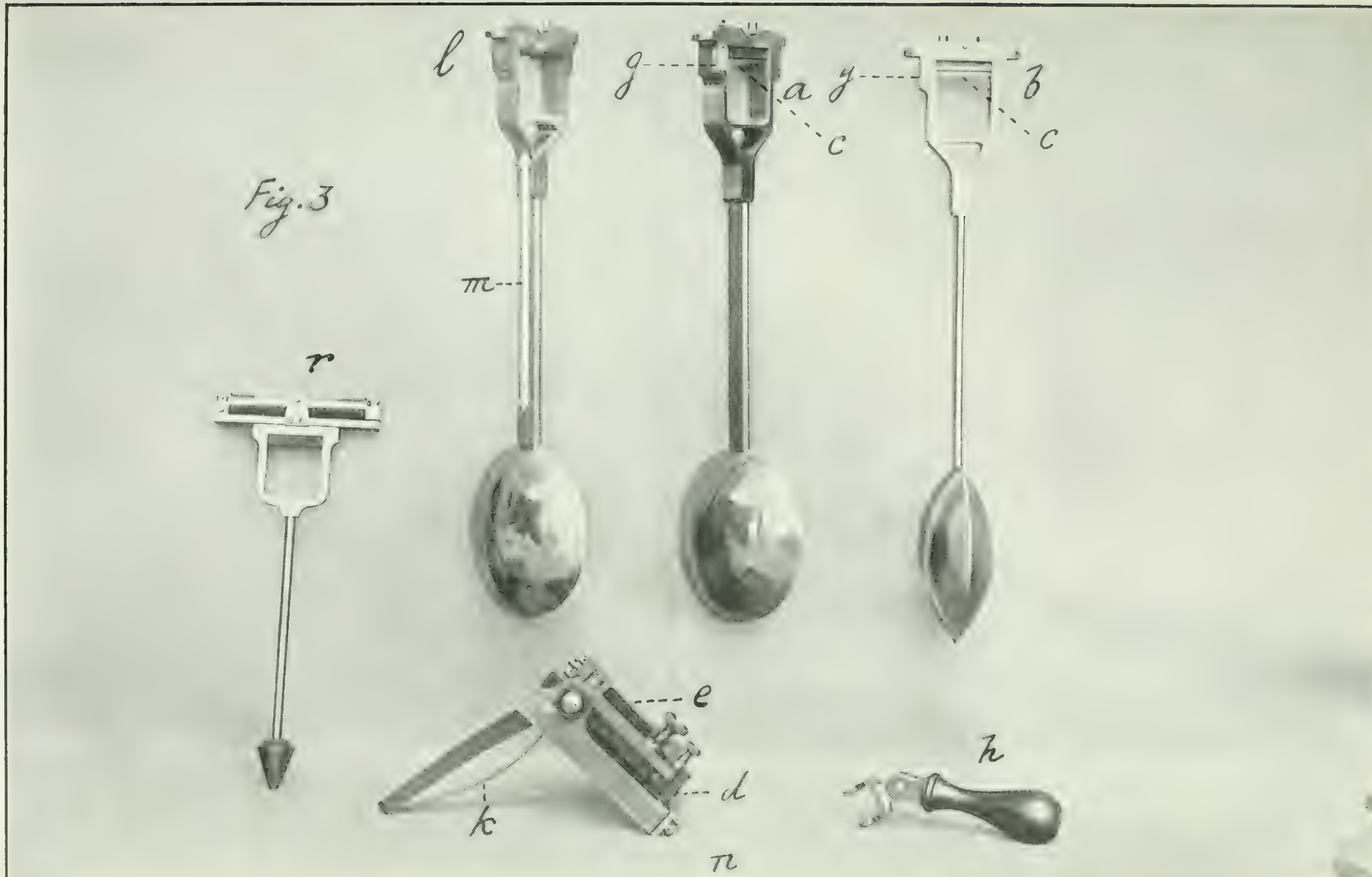

Fig. 3.—Pendulum Apparatus.

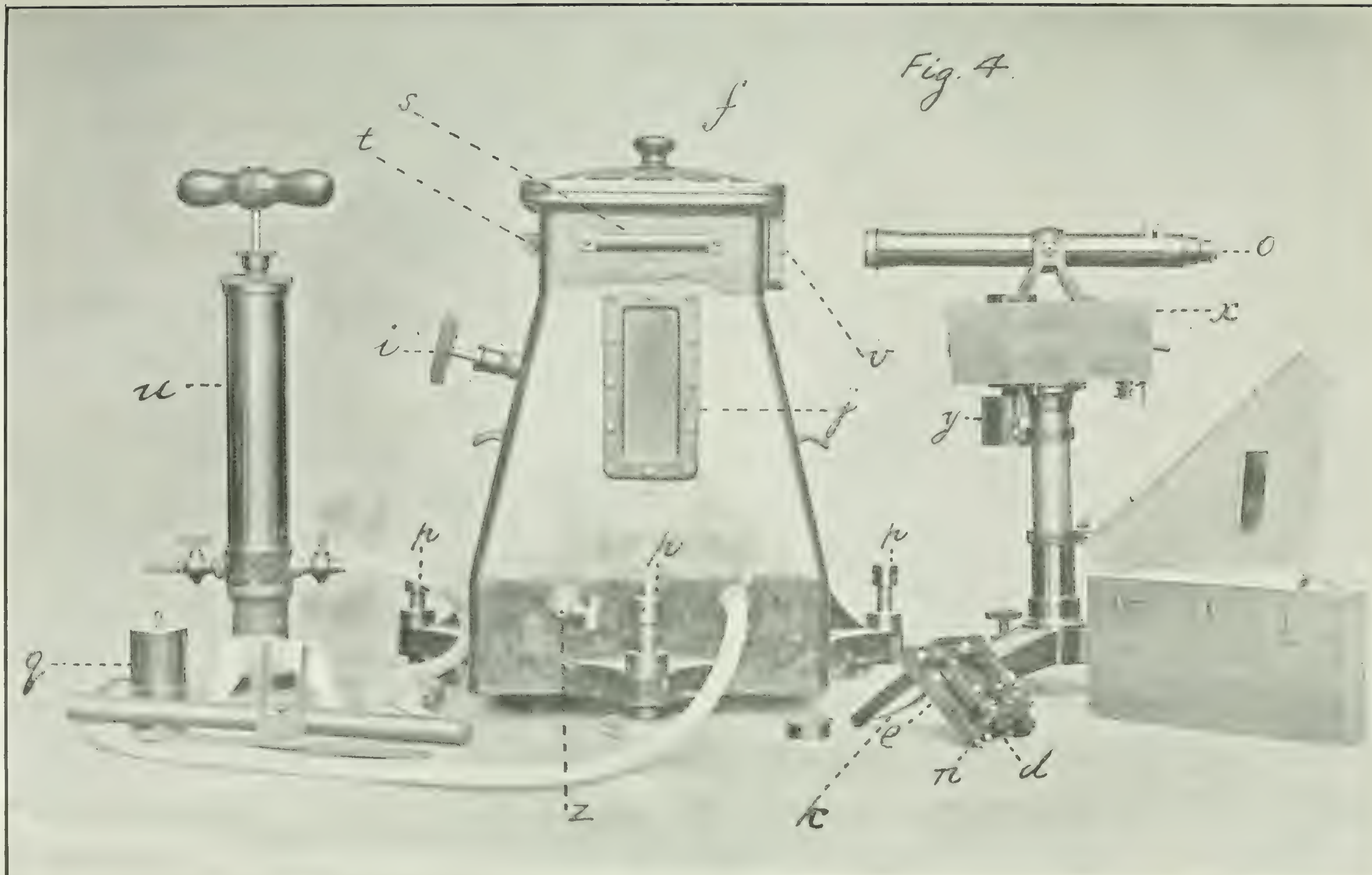

Fig. 4.—Pendulum Apparatus.

APPENDIX 3.

REPORT OF THE CHIEF ASTRONOMER, 1905.

TRANSPACIFIC LONGITUDES BETWEEN CANADA AND AUSTRALIA AND NEW ZEALAND, EXECUTED DURING THE YEARS 1903 AND 1904

BY

OTTO J. KLOTZ, LL.D.

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DEPARTMENT OF THE INTERIOR,
OFFICE OF CHIEF ASTRONOMER,
OTTAWA, CAN., December 30, 1905.

W. F. KING, Esq., LL.D.,
Chief Astronomer,
Ottawa.

SIR,—I have the honour to submit the final report on 'Transpacific Longitudes' carried out under my charge.

With me in the work was associated Mr. F. W. O. Werry, B.A., as observer, and he occupied Fanning and Norfolk islands.

Mr. F. A. McDiarmid, B.A., attended to the clock exchange at Bamfield, Vancouver Island, with the observatory at Vancouver and the one at Fanning. He also computed all the transits.

I occupied Vancouver; Suva, Fiji; Southport, Queensland; and Doubtless Bay, New Zealand, besides the observatories at Brisbane, Sydney and Wellington for personal equation.

I have the honour to be, sir,
Your obedient servant,
OTTO J. KLOTZ.

REPORT ON TRANSPACIFIC LONGITUDES BETWEEN CANADA AND AUSTRALIA AND NEW ZEALAND, EXECUTED DURING THE YEARS 1903 AND 1904.

NOTES ON THE BRITISH PACIFIC CABLE.

On December 31, 1900, articles of contract were made by Her Majesty's Government, Canada, New South Wales, Victoria, New Zealand and Queensland on the one part and the Telegraph Construction and Maintenance Company on the other, for the construction and laying of the Pacific Cable.

The contract called for the completion of the whole cable on or before December 31, 1902. The cable was finished two months earlier, and after undergoing the required test of a month, entered upon its commercial career on December 8, 1902.

Thus was the project, that had been advocated with persistence from some quarters for a quarter of a century, made an accomplished fact. The missing link of about 8,000 miles across the Pacific between Canada and Australia in the world's metallic girdle was now supplied.

Before the cable was laid a survey was made of the route and the character of the ocean bed examined.

From the survey the number of miles (nautical) of cable required for the different sections was as follows:—

From Vancouver Island to Fanning Island	3,654
" Fanning Island to Suva, Fiji	2,181
" Suva to Norfolk Island	1,019
" Norfolk to Queensland (Moreton Bay)	906
" Norfolk to New Zealand	513

The first section of the cable is about a thousand miles longer than any that had been laid before. This necessitated a considerable increase in copper for the conductor and in gutta percha for the dielectric. The working speed of a submarine telegraph cable depends on, and is inversely proportional to, the product of the total resistance of the conductor multiplied by the total electro-static capacity of the core, so that, other things being equal, the speed varies inversely as the square of the length of the cable. In the long section there were used 600 lbs. of copper and 340 lbs. of gutta percha per nautical mile. On the Fanning-Suva section 220 lbs. of copper and 180 lbs. of gutta percha; and on the remaining three sections the copper and dielectric were in equal proportions of 130 lbs. each.

In the neighbourhood of Fiji at a depth of 2,500 fathoms, a temperature of 34°·1 Fahrenheit was noted, being the lowest temperature taken during the survey. There is very little difference in the temperature of the ocean at great depths, say below 3,000 fathoms, over a great extent of the earth's surface, the temperature being only a few degrees above freezing point, or 32° Fahrenheit. The greatest depth, 3,070 fathoms, about three and a half miles, was found on the Fiji-Fanning section, where the bottom specimens consisted principally of radiolarian ooze. This ooze is found at the greatest depths, and was obtained by the *Challenger's* deepest sounding in 4,475 fathoms. The United States steamer *Nero* sounded in 5,269 fathoms, 6 miles (this last being the deepest sounding recorded in the ocean), and the material brought from the bottom was radiolarian ooze.

Of the 597 samples of sea bottom obtained on the Pacific Cable survey, 497 were such that they could be divided into distinct types of deposits. It was found that;—

294	samples	referred to	globigerina ooze.
65	"	"	red clay.
43	"	"	radiolarian ooze.
45	"	"	coral mud or sand.
27	"	"	pteropod ooze.
12	"	"	blue or green muds.
11	"	"	organic mud or clay.

The pressure at a depth of 3,000 fathoms, in which a considerable portion of the Pacific Cable is laid, is about four tons to the square inch. When the cable is being laid at such depths, it will be approximately twenty miles astern of the ship before it touches the bottom.

Deep sea cables last longer in the tropics than in the northern oceans. The reason is to be found in the fact that in the tropics marine life, from which globigerina ooze is derived, is more abundant than in the more northerly or southerly waters. It is the sun and the warm surface water that call into life these countless globigerina, which live for a short space, then die and fall to the bottom like dust, making such a good bed for the cable to rest in. In the Arctic currents, where the surface is cold the water does not teem with life in the same way as it does in the tropics, and consequently there is less deposit on the bottom of the ocean.

A submarine cable consists, first of a core, which comprises the conductor, made of a strand of copper wires, or of a central heavy wire surrounded by copper strips as in the Pacific Cable, and the insulating covering, generally made of gutta percha, occasionally of india rubber, to prevent the escape of electricity. As far as cabling is concerned, this is really all that is necessary, an insulated conductor. This, however, would not, in the first place, be sufficiently heavy to lay in the ocean, and secondly, would be too easily injured and destroyed by the many vicissitudes to which it would be subjected. For this reason, a protection in the form of a sheathing of iron or steel wires surrounds the core; the nature, size and weight of the sheathing being dependent upon the depth of the water and kind of ground over which it has to be laid. The deep sea section, being the best protected from all disturbing influences outside of displacement of the earth's crust by earthquakes or volcanic action, is naturally the one of smallest dimensions; and for the shore end, which is exposed to the action of

the waves, to driftwood, to the grinding of ice in the more northerly latitudes, and to the danger of anchorage, especially of fishing boats, the sheathing must be very heavy. So that while the deep sea cable is somewhat less than an inch in diameter, that for the shore ends is nearly 2½ inches in diameter. The action of the waves is limited to a depth of only about 13 fathoms, so that their influence on the cable, manifested by wear and chafing, is confined to the shore end.

The Pacific Cable is equipped with the most modern apparatus at the various stations, and the cable is worked duplex, that is, messages are sent and received on the same cable at the same time.

Canada had carried longitude work from Greenwich across the Atlantic and thence to Vancouver. The completion of the British Pacific Cable offered an opportunity for continuing the work across the Pacific in the interests of navigation and geography, besides tying for the first time longitudes brought eastward from Greenwich with those brought westward, making the first longitude girdle round the world.

In October, 1902, the Honourable Mr. Clifford Sifton, Minister of the Interior, authorized the carrying out of the Transpacific longitudes, and the Governors of the South Sea, Australia and New Zealand were respectively officially notified thereof.

In preparing the programme for carrying out the work, the climatic conditions of the various stations to be occupied were studied so that the most favourable times and seasons might be chosen. It was found that Suva, Fiji, was the governing factor, as it was by far the rainiest place of the series.

Besides the transit outfit, I carried, too, a half-seconds pendulum apparatus, and a Tesdorpf magnetic instrument, the latter similar to the ones furnished to Drygalski of the *Gauss* on his Antarctic expedition.

ITINERARY.

Mr. Werry left Ottawa on February 27, 1903, and proceeded to San Francisco, whence he sailed for Samoa, where he took the northbound steamer for Fanning island. The southbound steamers in passing Fanning do not call there. In the latter part of March, Mr. McDiarmid and I proceeded to Bamfield, Vancouver island, the eastern terminus of the Pacific Cable. After installing the sideral clock and its connection with the cable, I returned to the Vancouver observatory to begin observations. Bamfield, where no observations were taken, was simply used as a clock exchange station for making comparison between the Fanning and Vancouver clocks.

By the end of April a satisfactory number of observations had been obtained at Fanning and at Vancouver, and the first link of the Transpacific longitudes completed.

I took passage on the Canadian-Australian steamer *Miowera,* and sailed on May 2 for Suva, Fiji. We called en route at Honolulu. Here were met the two American astronomers, Mr. Edwin Smith and Mr. Fremont Morse, who were engaged in the determination of the difference of longitude, San Francisco-Honolulu. Suva was reached May 20, and immediate steps were taken for the erection of the pier and the observatory. The Fanning-Suva longitude was completed on June 24. It may be stated that as Suva is just west of the 180th meridian, and Fanning east of it, the dates for the observations of the same night differ by a day. Mr. Werry left Fanning on June 27 for Norfolk island some 3,000 miles distant. This necessitated a rather circuitous route of about 7,000 miles for lack of suitable steamer connections. He had to return to Honolulu thence to Samoa, Auckland, New Zealand, Sydney, Australia, and finally to his destination, which he reached in the beginning of August, occupying about six weeks to reach the cable station at Norfolk island. During this interval I made pendulum and magnetic observations at Suva, and also paid a visit on invitation of Roko Kandavu, grandson of the great cannibal king, Cakobau, the present ruler, at the old Fijian capitol on the small island of Bau, some 20 miles from Suva.

About a month was occupied in determining the difference of longitude, Suva-Norfolk. On September 7 I sailed on the *Aorangi* for Brisbane, where we arrived on Saturday, the 12th. On the following Monday I proceeded by rail with the astronomic outfit of many cases to Southport, the cable station, fifty miles south of Brisbane.

Mr. H. C. Russell, government astronomer at Sydney for New South Wales, hearing of my arrival, immediately wired his hearty co-operation in connecting Sydney with Southport. Similar co-operation was readily granted by Mr. A. A. Spowers, Chief Surveyor for Queensland, with the Brisbane observatory in charge of Mr. T. D. Fraser. By September 25 the pier and observatory were built and observations begun. Southport formed a unique station, for nightly clock exchanges were had in succession with Brisbane, with Norfolk and with Sydney, at each of which time observations were being taken. It was on September 29 that the first mutual observations and clock exchange were had with Sydney, and so this night may be considered as the one when for the first time longitude from the west clasped hands with longitude from the east, and the first astronomic girdle of the world was completed.

By October 16 the last link, Norfolk-Southport, of the direct Transpacific longitude was completed. Mr. T. D. Fraser and I observed for personal equation at Southport and at the Brisbane observatory. Magnetic observations at Southport were also taken. On November 3 I arrived at Sydney, and after observing for personal equation, with the two observers, Mr. H. A. Lenehan, acting government astronomer, and Mr. W. E. Raymond, left on November 7 for Wellington, New Zealand. Here I was met by Sir James Hector, the former director of the observatory, and by Mr. Thomas King, who now has charge of the time observations. The Premier, the Honourable R. J. Seddon, extended every facility the government could offer to further the success of the work. Observations were made for personal equation by Mr. King and myself. After making the necessary arrangements for subsequent clock exchange signals at the observatory, I left for the cable station at Doubtless Bay, at the north end of New Zealand, going by rail to New Plymouth, thence by steamer to Onehunga, across the narrow isthmus by rail to Auckland and thence by steamer to Mangonui, the most northerly port on the east coast. From there I had to drive over an execrable road some miles to the cable station. Here a pier and observatory were built similar to the ones at Suva and Southport. Longitude observations were begun on December 3 and finished on December 19. Before leaving this station a set of pendulum observations was obtained, and the magnetic elements were also determined.

Returning to Wellington, another set of personal equation observations was taken, and similarly in Sydney in January, 1904.

This completed the work of the Transpacific longitudes.

I wish here to express thanks for the hearty co-operation of the chief electrician of the Pacific Cable and of the superintendents at all the stations; of the superintendents, Mr. Hesketh, of the government telegraphs in Queensland; Mr. Young, for New South Wales, and Mr. John Logan, for New Zealand. Mr. G. A. Buzacott, Deputy Postmaster General of Queensland; Mr. J. Dalgarno, for New South Wales, and Sir Joseph Ward, Postmaster General of New Zealand, kindly placed the use of the respective telegraph lines at my disposal for the nightly clock exchanges.

At the Wellington observatory batteries and telegraph instruments had to be installed for the clock exchanges with Doubtless Bay. This was done by Mr. Buckley, government electrician, who also kindly attended every night during the campaign at the observatory to the exchange of signals. In short, wherever and whenever any assistance was required it was readily and cheerfully extended, and the success of the work is in no small measure attributable thereto.

The number of stations between Vancouver and Australia, as well as between Vancouver and New Zealand, is odd, and as the two observers occupied alternate stations, the terminal stations, Southport and Doubtless Bay, are each free by this means from personal equation.

KLOTZ—INSTRUMENTAL EQUIPMENT.

Transit.—The transit (Fig. 1) is by T. Cooke and Sons, and known as No. 504 of their catalogue, 1900, with slight modifications. This instrument was specially ordered for the Transpacific longitude, and was received only a short time before departure for Vancouver, where it was mounted for the first time, and the large inequality of pivots discovered. It has an object glass of three inches, clear aperture, and is mounted in a tube of double conical shape with dew-shade; focal length about 36 inches, axis 1¼ inches in diameter, Y's 1$\frac{1}{16}$ inches in width; the support of each end of the axis is two cylindrical segments having arcs ⅝ inch long.

The telescope is provided with two 6¾-inch setting circles reading by verniers to 20 seconds of arc. One of these circles is provided with a special arm for carrying the latitude level, when using the transit as a zenith telescope. Above the level there is a device for an attachable mirror, a strip of silver glass set in a metal frame. In using the transit as a zenith telescope the level readings cannot be satisfactorily read for stars near the zenith, as one end of the bubble will be directly behind one of the transit standards. To avoid parallax in reading the level, the mirror, secured at an angle of 45 degrees, and at the height of the eye, overcomes the difficulty.

A striding level is provided. The vial rests on cork tips, and is retained in position by light cork tipped springs. There is a glass covering to prevent sudden change of temperature of the vial. A single wooden knob on the level frame serves for handling the striding level. On account of the long legs it was found necessary to attach lateral legs to prevent accident from toppling over through gusts of wind or other cause. A dew-cap 6 inches long is used when observing. The eye-piece attachment carries a micrometer for the movable thread used for latitude work. The micrometer is divided into a hundred parts, equivalent to about 56 seconds of arc, so that by estimation to tenths of a division, about six-hundredths of a second of arc may be read. The eye-piece attachment with micrometer may be turned through 90° from the ordinary position when observing transits, in order to make the movable thread available for measuring zenith distances in latitude work. Instead of having a comb for counting the revolutions of the micrometer there is a small, toothed, geared and numbered wheel outside to effect the same purpose. This has the advantage of obviating erroneous counting which may happen with the comb in counting from left to right, instead of from right to left or vice versa.

Of the different eye-pieces with which the telescope is provided the same rectangular (erecting) eye-piece was used throughout. The eye-piece is set in a cross-slide with quick-traversing screw and milled-head.

There are on the diaphragm thirteen spider threads, two outside ones and then two groups of three each placed symmetrically about a middle group of five threads. The equatoral interval between two adjoining threads in a group is about 1·6 seconds of time. The illumination of the threads was effected through the hollow axis by an oil lamp, placed on an arm 9 inches long. To prevent unequal heating of the axis, a lamp was placed at each end of the transit axis. Lucca oil is found the most satisfactory for burning in the small instrument lamps.

The transit was supplied with reversing apparatus. The cast-iron stand rested on a base-plate and was supported by three large screws, one at one end and two at the other, fitting into spherical holes in the base-plate. For meridional adjustment two opposing screws at the foot of the stand and near the supporting screws acted on a projection on the base-plate, the levelling was done by the single supporting screw at one end. The base-plate was not bolted to the cement capping of the pier. The weight of the whole instrument and plate was sufficient to retain the latter in a permanent position with reference to the pier.

Clocks.—Two clocks or rather chronometers were carried. They were adjusted to sidereal time. Both had break-circuit electrical attachments.

Dent No. 48419 had two-second breaks at the even seconds, omitting the 58th second break in order to indicate the 60th or minute break.

To the inside of the outside case were attached maximum and minimum thermometers and an ordinary thermometer within the chronometer box proper. One dry cell was generally found sufficient for the clock circuit, and would retain its efficiency for two months. During the day time when not observing, the clock circuit was of course left open. The clock at each cable station was placed in one of the 'artificial line' cabinets, so that its temperature might be as uniform as possible. The fluctuation in temperature during the twenty-four hours was small, being confined within about two degrees Fahrenheit. At Vancouver the chronometer was kept in a small brick vault near the observatory, used for storing the powder for the signal gun, a quarter of a mile distant, which is fired daily at 9 p.m. Pacific standard time. Insulated copper wire connected the clock with the switchboard in the observatory, hence with the chronograph circuit; and by another set of wires with the sounder on the pier of the cable instruments, by means of which, as more fully explained elsewhere, the clock was made to record its beats by a special siphon on the cable fillet of paper.

The clock was wound daily at 4.30 p.m.

Bond No. 516 made two second breaks also; instead of omitting the 58th second break, however, a break for the 59th second was interpolated to identify the following one for the full minute.

Chronograph.—A Fauth (Saegmüller) barrel or cylinder chronograph was used. The cylinder was 6¾ inches long and 4 inches in diameter. It was geared to two speeds, but the slower speed of one revolution per minute was the one always used. A Waterman fountain pen answered the purpose as recording style, but it requires attention. The perversity of some things at times seems inexplicable.

The pen, being actuated by the small armature of the magnet of the chronograph, and the electric circuit of the latter by the clock, also by the observing key, records both the clock and star transit.

It was customary to use one chronograph sheet for each position of the instrument, so that for a complete set there would be four sheets for a night's observations, and an extra sheet when there was an exchange of clock signals over land lines. The chronograph sheets are infinitely more convenient for scaling a set of observations than the Morse fillet so common in the European observations. For subsequent reference too the sheet is vastly superior to the yards or fathoms of fillet.

The measurements on the chronograph sheets were made by means of a convergent-divergent glass scale, covering the two-second spaces, and dividing the same into tenths of a second, which by estimation were read to hundredths. Fig. 2 shows one of the chronographs used.

Levels.—Both the latitude and striding levels used were supplied with the transit by T. Cooke & Sons.

Their value was determined before and after the work by means of a level-trier, 114·40 inches between the pivots, and the Whitworth micrometer screw for raising and lowering one end of the trier read directly to one-thousandth of an inch. Determinations for value of one division of level were also made by placing the level longitudinally on the telescope tube of transit No. 2, then comparing the displacement of the bubble with the corresponding angular movement of the telescope as measured by the micrometer on some distant fixed object.

The method by level-trier is more accurate than the one by the micrometer, as the latter involves the uncertainty of constant bisection with the micrometer thread.

Electrical Apparatus.—The switchboard which has been used for many years very satisfactorily in connection with the Canadian transcontinental longitude work, was used at every station. For clock exchange by cable all its parts were not required; it then only served for the observations themselves by making the necessary connection between clock, chronograph and observing key.

However, at Vancouver, Southport and Doubtless Bay, where clock exchange signals were made over land lines and the conversation was done over the wires from the observatory, all parts of the switchboard were brought into requisition.

The accompanying diagram (Fig. 3) will illustrate the various parts and connections of the switchboard.

When observing, the switch is to the left, and plug 1 is in. The chronograph circuit is broken by the chronometer at the points of the clock relay, as well as by the observing key.

For simply talking over the line the switch is to the left, plug 2 in, plug 3 out, and also plug 8 out if the sounder is to be used. Experienced operators do not need the sounder but read off the relay.

For clock exchange, both clocks (of the two stations) beating simultaneously over the wire, the switch is put to the right, plugs 1 and 2 out; 3 may be out or in. When 3 is in, the talking relay is cut out. In clock exchange the main line current passes over the points of the clock relay and is there broken; similarly the distant clock breaks the local chronograph circuit at the points of the signal relay.

For arbitrary signals, sent with the break-circuit signal key, the switch is to left and plugs 1 and 2 out, so as to throw the chronograph circuit over the points of the signal relay. Under all conditions the chronometer always records on its own chronograph.

When the switch is to one side, the opposite points are in contact. The switch separates them, and changes thereby route of current. One dry cell (Mesco) is sufficient for the clock circuit. This is always independent of any other current, and to protect the points of clock contact only one cell is used.

For the circuit of the observing key and chronograph two or sometimes three cells are used.

Cable Attachment.—From former experience it was found undesirable to have a direct connection between the clock and the cable siphon, *i.e.*, to have the clock recording directly by means of the cable siphon. It is better to have an independent clock siphon tracing a line parallel to the one of the cable siphon.

To obtain the local clock record or two-second beats on the cable fillet, an ordinary sounder (Fig. 4) was provided with a 4½-inch long threaded rod attached vertically to one end of the sounder arm. Over the rod fitted loosely an oval ring held in position by two opposing screws and also by two nuts, one above and the other below the ring. The heads of the screws were perforated to admit of centering and fastening the silk fibre, to be spoken of presently. The sounder was screwed on a small board and the latter securely attached to the pillar on which the cable instruments are set, as it was found that by placing the sounder on the table the vibrations to which it was subjected by walking or other causes, made the siphon record unsatisfactory. On the brass frame (of the cable instrument) carrying the ordinary cable siphon was stretched another thin wire to which was attached a siphon which was connected by a raw silk fibre with the rod of the sounder arm, so that the siphon responded to the pulsations of the sounder and hence when filled with ink would leave a record on the cable fillet.

The recording of this siphon differed from that of the ordinary cable siphon, in as much as it dragged a continuous line on the fillet, while the other makes necessarily a dotted line, produced by the small vibrator tapping the frame. The magnetic effect, produced by the weak current used on cables, and which actuates latterally the cable siphon, is too weak to permit the siphon to rest permanently on the fillet, it could not draw it aside, so the siphon is kept just above the paper and by means of the vibrator is made to deposit drops of ink—about 60 per second—and thereby leave a record.

Before attaching the silk fibre to the sounder rod and siphon it was subjected to a constant pull by means of a small weight for a day in order to remove its elasticity sufficiently to permit of instantly responding on the siphon to the movements or pulsations of the rod. The tension of the fibre was adjustable by means of the two small opposing screws in the oval rings of the rod.

The local clock record on the cable fillet was necessary in order to be able to interpret the arbitrary signals sent from the other observing station and recorded by the cable siphon. In receiving signals there were two records on parallel lines on the fillet, the signals as shown by the cable siphon, and the clock beats shown by the other siphon. The trace of the latter was the foot-rule, so to speak, or scale for measuring the other. The two-second breaks in the line drawn by the clock siphon were projected vertically by a fine pencil line on the line of the cable siphon and the relative position of the arbitrary signals measured by a glass scale, similar to the one described, but somewhat larger, as the two-second breaks on the fillet were made considerably larger than those on the chronograph sheets. The speed of the fillet is adjustable by the small motor.

Although the siphons were generally placed fairly opposite each other, that is, in the same perpendicular to the fillet, yet it was necessary to know their parallax. To attain this end the local clock circuit was put in connection with one of the cable keys, the one (positive) used for sending arbitrary signals. A special arm was attached to that cable key so that when the cable key was depressed to make circuit and send a signal into the cable, the arm would at that moment break the local clock circuit, hence record the time on the fillet. By comparing the relative positions to a vertical of the break made by the cable siphon with that of the other siphon for an arbitrary signal, the apparent parallax of the siphons is obtained. To this parallax there may be a small outstanding correction due to want of perfect adjustment, that is, that the make of the cable key absolutely synchronizes with the break on the clock circuit. To obtain the absolute parallax the metal frame carrying both siphons was given a slight sharp tap, generally with the back of a pocket knife. By this means there was a momentary simultaneous displacement of both siphons and the parallax obtained, and by comparison with the above, an adjustment, if necessary, made.

The correction was always a small quantity—if anything at all—and about one-hundredth of a second of time.

Observing key.—This was an ordinary American telegraph key mounted on a small piece of wood. The spring adjustment was made weak, and the platinum points about a fortieth of an inch apart. The same conditions were maintained throughout the work. The moment the key was touched the circuit was broken and the transit recorded, independent of the spacing between the points of the key, which is not the case in a make-circuit key.

SYSTEM OF WORKING.

Programme.

It was decided that for each final differential longitude there should be five mutually complete nights or their equivalent.

Time set.—A complete night's programme comprised twenty-eight stars, divided into four sets of seven stars each. One of the seven being a polar, while the others were distributed between the zenith and an equatorial zone.

Two of these sets—one clamp east and one clamp west—comprised a time determination, so that each night, when clear, there would be two independent time determinations, and a measure of the individual hourly clock rate obtained, beside the daily rate shown by the observations of successive days.

For the northern hemisphere the Berliner Jahrbuch has generally been used for the selection of stars, but for the southern hemisphere the British Nautical Almanac furnished the most suitable stars. Both were supplemented by the American Ephemeris and Connaissance des Temps. On account of the difference in longitude between any two stations, and for other reasons it was not practicable for the two observers to use the same sets of stars for the purpose of eliminating errors in right ascension, which in the standard stars alone used is supposedly a very small quan-

tity. The programmes were always so arranged that each observer would, with clear sky, have completed his first time determination, that is, would have observed one set clamp east and one set clamp west, before the time of exchange, generally at 9.30 p.m., of clock signals. These signals would therefore fall between the first and second independent time determinations. It is all-important that the respective clock errors be accurately known at the time of exchange of clock signals. This is best obtained and assured when there is a time determination immediately preceding and one immediately following such exchange. Through clouds or rain, or other unpropitious weather it was not always possible to obtain the time determination when desired.

Exchange on Cable.—Along the whole system of the Pacific cable Greenwich mean time is used for the commercial work. For Fiji through which runs the anti-meridian of Greenwich, the Greenwich mean time 12 hour clock dials would practically show local time for Suva. It was desirable in the cable offices that the time for exchange of clock signals be fixed at some definite time so that the officers could govern themselves accordingly and have the spare cable instrument in readiness at the appointed time. The time was so arranged that the westerly observer had time to obtain his first time determination before the exchange. In the tropics observing may be begun almost immediately after sunset, as there is little twilight. The exchange consisted in each observer sending alternately not less than thirty arbitrary signals at irregular intervals, averaging about two seconds apart, the interval being always sufficiently long to permit the siphon to have well resumed its normal position in tracing the zero line of dots on the fillet. The signals having been mutually and satisfactorily received, the record of the night's work and of the preceding night was mutually communicated, and this ended the use of the cable for the night. If all went well, the whole exchange of signals and communications would occupy less than ten minutes. This was, however, not always the case; the ink in the siphon might give trouble, or the vibrator, or some other vicissitude for which one must always be prepared not only at the cable instrument, but also in the observatory.

Throughout the whole work, received signals were scaled by Klotz on the cable siphon record, by projecting the 2 second breaks of the clock on the lower or clock siphon record upon the upper one. This method was preferred to projecting the received signals (beginning of deflection of cable siphon) on the lower line to avoid obliterating or obscuring by a pencil line as ordinate the dot or dots (vibration of siphon) indicating the arrival of the signal. In the method pursued, after adjusting the glass scale to cover the intersection of the ordinates from the clock breaks with the zero line of the cable siphon, one could deliberately determine the first indication of the cable siphon leaving its zero line of undisturbed position.

The scaling of the signals sent, which were recorded by both siphons, was always done on the clock siphon record, hence it is necessary to apply to all scaling of signals received, which were recorded of course only on the cable siphon, the parallax of the cable siphon. This parallax was readily obtained from the signals sent, because in that case we have the record for each signal by the two siphons. To test the adjustment of the cable key with the local clock circuit, *i.e.*, whether the two siphons recorded simultaneously, the cable key make and the clock circuit break, the frame carrying the two siphons was lightly tapped after the exchange of signals thereby making simultaneously a break in the two lines made by the siphons, and the absolute parallax expressed in time found. If the apparatus is well adjusted, this absolute parallax is identical with the one obtained as described above. When a difference was found it was confined to about one-hundredth of a second.

Mr. Werry invariably scaled the cable siphon record both for sending and receiving signals on the clock siphon line by projecting the same on that line. The parallax of the siphons was obtained in a manner similar to the one described above.

The accuracy with which a comparison between two clocks or chronometers can be made by means of a cable, is practically only a matter of careful scaling of the time signals on the tape. So that with the tape running out approximately an inch

a second it is found that an exchange of thirty signals gives a probable error for the mean difference of the two chronometers of less than ±^{s}.002. Small as this quantity is, it includes error of scaling, irregular running out of tape, irregularity of clock beats, and differential rate.

Compared with the many other quantities—star places, level readings, temperature with its hidden effects on instrument and chronometer, errors of observation, personal equation—entering into the determination of the difference of longitude, the probable error of an exchange of time signals is almost a vanishing quantity. The same remark holds true for an exchange over land lines. Fig. 5 illustrates a cable record, both receiving and sending.

Clock Exchange on Land Lines.—Land line exchanges were made between Vancouver and Bamfield, Southport and the observatories at Brisbane and Sydney, the former fifty miles distant by wire, and the other 753 miles. Also between Doubtless Bay and the observatory at Wellington, 704 miles. The exchanges were effected without the interposition of relays on the line.

It was customary to allow both clocks to record over the wire at the same time and record on the chronographs of the two stations. This was a mere check on the actual exchange by arbitrary signals and to show the relative position on the chronographs of some one minute (the 60th second) of the one clock and some one minute of the other clock. Experience has long shown that a more accurate comparison between two clocks can be made by arbitrary signals, that is by breaking the local clock circuit as shown on the chronograph, and by that same depression of the key, breaking the main line and hence sending a signal to the distant station there to be recorded on the chronograph, than by simply allowing the clocks to record over the line. The particular merit of the arbitrary signals lies in the fact that in scaling the chronograph sheets the mind is and remains unbiased in making the measurements, whereas when scaling the record of the two clocks recording simultaneously on the chronograph, the mind involuntarily becomes biased after making one measurement. We know in advance what the remaining measurements should be. It is impossible to get rid of the influence of knowing in advance what to expect. This undesirable condition in exchange of clock signals is obviated by adopting the method of arbitrary signals. The measurements on the chronograph sheets as well as on the cable fillets were read to the one-hundredth of a second of time.

At the three observatories, Brisbane, Sydney and Wellington the Morse register with fillet of paper and two styles was used for recording the exchange of clock signals. It is somewhat surprising how tenaciously this form of chronograph is maintained not only at these observatories (Sydney had a drum chronograph too) but also at those in Europe. The cylinder chronograph is to one who has used both so manifestly superior for convenience of reference and reading and saving of time that it is difficult to understand why the Morse form is retained.

Rate.—Rate is one of the most difficult problems with which we have to deal in longitude work. It is not the magnitude of the rate, although a small rate is very desirable, but the constancy. This is the crux. A chronometer may have an apparently constant daily rate, yet the hourly rate for the twenty-four hours may and does vary. Again the rate is not the same when the current is on, as when it is off; the former condition obtaining when observing, and the latter the rest of the day. The rate deduced from two indepedent time determinations of the same night, when the temperature is practically constant for the clock during the time of observation, and the clock is in circuit with the battery only during that time, is seldom, if ever, the same as that obtained from day to day observations.

In our programme we have two independent time determinations for each night. Each set of transits is reduced to the epoch of the mean of the times of transit of the stars comprising the set. The rate which is applied for each transit to the mean epoch, and for which some magnitude must be assumed, is practically a vanishing

quantity in the resulting clock correction. The ideal time of exchange would be at that epoch, when the effect of rate is eliminated. But for various reasons this is found to be impracticable. In the programme then of two independent time determinations, for obvious reasons the exchange was arranged to take place about midway between the two epochs. An interpolation between the two epochs gives the clock correction at the instant required, that of the signals. This assumes that the rate is constant during the interval, and is represented by a straight line. If extrapolation is necessary, as sometimes occurs, the rate value has less weight.

Transmission Time.—On the assumption that the time of transmission is the same in both directions and that the chronometers have the same rate, the difference of records at two stations of the exchange of time signals will represent twice the time of transmission.

We are obliged to assume that the transmission time is the same in both directions, but to the difference of the records of exchange of time signals there must be applied the relative rate for the interval between the means of the times of the two exchanges. This interval is confined to about two minutes.

From the two independent time determinations made at each station on the same night the hourly rate of each chronometer when in circuit is obtained. The algebraic difference of these hourly rates gives the relative hourly rate of the two chronometers and the proportional part for the above interval is the quantity entered in the column 'Relative rate' of Table......

On exchange by land-lines, it will be seen, referring to the diagram of the switchboard that the deduced transmission time is free from any retardation by the signal relays or by the secondary circuits of the chronographs. The effect upon the comparison of the clocks of retardation by the signal relays and secondary circuits will disappear in the mean of the two exchanges provided the sum of the retardations by signal relay and secondary at one station is equal to that at the other. This condition is, however, not necessary for finding the time of transmission.

Personal Equation.—Fortunately for the connection between Canada (Vancouver) and Australia (Southport), also New Zealand (Doubtless Bay), the personal equation between the two observers was eliminated. This is, of course, on the supposition that the personal equations remained constant. As the climatic conditions, as far as temperature was concerned, and the surroundings were favourable for personal comfort, there was no *a priori* reason for suspecting any change during the campaign in the personal equation. The elimination referred to was due to the fact that the number of stations was odd, and that the observers occupied alternate stations. I occupied the terminal and middle stations, while Mr. Werry occupied the other two—Fanning and Norfolk islands,—and for these two stations differential personal equation must be applied. To determine such we observed on our return with the same two transits of the Transpacific longitude, on several nights in a manner identical with that at work in the South seas, and under similar climatic conditions. It may be remarked that it was impracticable before leaving Ottawa to observe for personal equation. In the first place it was winter, thermometer below zero, and secondly my Cooke transit had not yet arrived when Mr. Werry set out for Fanning island, via Samoa.

For the longitude of Brisbane, Sydney and Wellington, I observed with each of the observers at the respective observatories, by determining the clock correction for the respective common epochs.

Instrumental Constants.

Thread Intervals.—These were determined by both instruments by observing the transits of slow-moving (polar) stars and the intervals were all referred to the mean and not to the middle thread. The times of transit are corrected for level (if any change of level has taken place during the transit) and for rate. Multiplying the

time interval of any thread from the mean thread by the cosine of the star's declination gives the equatorial interval for the same. For circumpolar stars, whose motion during the time of transit from one thread to another is sensibly an arc of a circle the interval must be further multiplied by the cube root of the cosine of the hour angle of the star for the respective threads.

The following are the values of the equatorial intervals for Klotz transit, determined from transits of α Crucis, γ Trianguli, α Trianguli and β Chamaeleontis.

Clamp East.

	s.
1	− 9·939
2	− 8·273
3	− 6·690
4	− 3·279
5	− 1·640
6	+ 0·036
7	+ 1·576
8	+ 3·200
9	+ 6·662
10	+ 8·352
11	+ 9·995

For the Werry transit, the values determined from transits of λ Centauri, α Crucis, Groombridge 1930 and 8 Draconis are:—

Clamp East.

	s.
1	−14·209
2	−11·903
3	− 9·573
4	− 4·794
5	− 2·196
6	− ·110
7	+ 2·454
8	+ 4·681
9	+ 9·591
10	+11·906
11	+14·153

Inequality of Pivots.—The Klotz transit was received from the maker in the dead of winter and just prior to leaving for the Pacific so that no opportunity was afforded to determine any of its constants at Ottawa.

The inequality of pivots was determined both by special series of observations and also from the many level readings just before and after reversal of transit in the daily (clear nights) time determinations.

In this transit there was a considerable change in the inequality of pivots from April to December. For Vancouver and Suva the values are identical, thence onward there is an increase for Southport and still more for Doubtless Bay. The cause of the change is not apparent. Before beginning observing in Southport I removed with great difficulty the plug carrying the lens in the clamp end of the axis as the inner surface of the lens was covered with brass filings. In re-inserting the plug I did not get it quite 'home.' This might perhaps have affected the diameter of that pivot. Whatever the reason, the quantity was accurately determined and applied to the level correction.

The mean value for Vancouver of seven determinations gave for p the pivot inequality correction $^s.080$, the inequality being twice that quantity.

A similar determination at Suva gave $p = {}^s.080$.

At Southport a double series was taken, one by continuous readings on many reversals, the other from many nights level readings during the time of transit observations. From these we obtain $p = {}^s.117$.

At Doubtless Bay the value was obtained from level readings extending over the whole period of time determinations in December and the resulting value for the correction of inequality of pivots is $p = {}^s.151$.

All the corrections are additive for clamp east, the axis opposite the clamp being the larger. The respective values of p were applied for each station.

Level.—The value of the striding level of Klotz transit was obtained from two series of readings on different days, by placing the striding level longitudinally on the telescope of the Werry transit. The telescope was clamped in a position to allow the bubble in the striding level to play near one end of the tube. By means of the micrometer and its thread a reading was taken on a distant object. Then by means of the tangent screw of the telescope, the latter together with the level was displaced. This displacement was measured by the micrometer screw and expressed in angular measure. Repeated and satisfactory measurements were thus obtained.

The mean value of one division of the level at 68° F. is $^s.085$.

By the use of the level trier the mean value of the striding level (a Pessler) of the Werry transit was found to be $^s.100$.

Micrometer.—The value of the micrometer of either instrument was not required in the longitude work, only for the latitude determinations, by using the transit as a zenith telescope and observing by Talcott's method. The value of the micrometer was obtained from a series of transits of slow-moving stars over the micrometer thread, set in advance at intervals of five revolutions. The times of transit were corrected for rate and for hour angle. The mean of the time intervals was taken and reduced by multiplying by the cosine of the star's declination.

From such observations the value of one revolution of the Klotz transit micrometer was $56''\cdot878$.

That for the Werry transit is $60''.556$.

Diurnal Aberration.—The correction for diurnal aberration was obtained for each star by the usual formula $-{}^s.0207 \text{ Cos. } \phi \text{ Sec. } \delta$ and applied to the time of transit, ϕ and δ being the latitude and declination respectively.

For lower transit the correction is positive.

Collimation.—The correction for collimation was determined from the simultaneous reduction of a set (clamp east and clamp west) of transits for time.

No direct measures were made by means of observations with collimating telescope or mercury collimator.

Azimuth.—For the determination of the deviation of the transit instrument from the meridian a polar or slow-moving star was observed in each position of the instrument in the set of time observations. The value was obtained as in the preceding case from the simultaneous reduction of the condition equations constituting a time determination. As the principal unknown sought is the clock correction, the stars comprising an observation set may be so chosen that both the collimation and azimuth corrections, irrespective of magnitude, have little effect on the deduced time.

Reduction of Observations.—As already stated a complete time determination consisted of the observation of fourteen stars, seven for position clamp east and seven for clamp west.

On a clear night two of such determinations were made. For each position there was one polar star the others being time stars. The mean of the eleven threads was taken for the time of transit. This time was corrected for level, inequality of pivots,

aberration and rate, giving thereby the corrected time of transit, but still involving the azimuth and collimation corrections besides the clock error.

The right ascensions for a given date were interpolated from the respective ephemerides, and 'the corrections to the R.A. of the Nautical Almanac' as well as of the Berliner Jahrbuch, were applied.

Assuming then a clock correction ΔT for the mean clock time of the transits of a set, and to which time the rate was referred for obtaining the rate correction, we have for each star observed a condition equation of the form,

$$\Delta T + \delta T = (a - t) + Aa + Cc.$$

where $\Delta T + \delta T$ is the clock or chronometer correction. From the fourteen (or less) condition equations the three normal equations are deduced in the usual manner, and the three unknowns determined. As a rule, after beginning observing no attempt was made to level the instrument, but instead frequent readings of the level were taken. There was only one azimuth deduced for one set of clamp east and clamp west, except in a few instances, which showed displacement in azimuth after reversal. This change was due either to reversal or to the levelling done at the time of reversal. The latter reason is apparently the one for the Werry transit, and may be explained by the unsymmetrical motion of the base of the heavy levelling screw in its socket in the base plate. The change in azimuth in the few cases became only apparent, when making the final reductions. In the recomputation for such cases the normal equations were solved for two azimuths, one for each position of the instrument.

Ordinarily the exchange of clock signals took place during the interval between the two independent time determinations which each observer made nightly, provided the sky was clear. The arithmetic mean corrected for parallax of siphons of the differences of the clocks from the individual signals was taken as the difference of the clocks at the mean time of all the signals sent from or received by the respective observers, so that there was no necessity for applying a correction for differential rate. The thirty-five arbitrary signals sent by each observer were usually comprised within less than two minutes. The differential rate, however, was applied for determining the time of transmission. That is, in comparing the differences between the clocks at the mean times of the two exchanges, differential rate was applied for the interval between the mean times of the two exchanges.

We have then two clock comparisons, and they differ from each other by twice the time of transmission.

To obtain the difference of longitude, the necessary data is now available, and a simple computation from the following formula gives the difference sought.

Let t_e and ΔT_{oe} = the chronometer time and its correction at the eastern station when sending a signal.

t_w and ΔT_{ow} = similarly for the western station, when receiving the above signal.

and t'_w and $\Delta T'_{ow}$ = the chronometer time and its correction at the western station when sending a signal.

t'_e and $\Delta T'_{oe}$ = similarly for the eastern station when receiving this signal.

μ = transmission time.

$d\lambda$ = difference of longitude, west longitude being reckoned positive.

We have then from an eastern signal.

$$d\lambda - \mu = t_e + \Delta T_{oe} - (t_w + \Delta T_{ow}) = d\lambda_e$$

and from a western signal,

$$d\lambda + \mu = t'_e + \Delta T'_{oe} - (t'_w + \Delta T'_{ow}) = d\lambda_w$$

$$\text{hence } d\lambda = \tfrac{1}{2}\ (d\lambda_e + d\lambda_w)$$

This is on the supposition that the relative personal equation has been applied to the chronometer correction, and furthermore, that the time of transmission from east to west is the same as from west to east, an assumption which must be made.

Hence we obtain also $\mu = \frac{1}{2}\ (d\lambda_w - d\lambda_e)$

If we let K = relative personal equation between the two observers the following formulæ express the difference of longitude for the several links across the Pacific, the observers occupying alternate stations.

Vancouver-Fanning $d\lambda^{I} = \frac{1}{2}\ (d\lambda^{I}_{e} + d\lambda^{I}_{w}) + K.$

Fanning-Suva $d\lambda^{II} = \frac{1}{2}\ (d\lambda^{II}_{e} + d\lambda^{II}_{w}) - K$

Suva-Norfolk $d\lambda^{III} = \frac{1}{2}\ (d\lambda^{III}_{e} + d\lambda^{III}_{w}) + K.$

and Norfolk-Southport $d\lambda^{IV} = \frac{1}{2}\ (d\lambda^{IV}_{e} + d\lambda^{IV}_{w}) - K.$

hence for Vancouver-Southport $dL = \frac{1}{2}\ (\Sigma d\lambda_{e} + \Sigma d\lambda_{w})$

That is, the difference of longitude between Vancouver and Southport, Australia, and similarly for Suva and Doubtless Bay, New Zealand, is free from personal equation even without knowing its magnitude, which, however, was determined, as stated elsewhere, for application to the Fanning and Norfolk longitudes.

The probable error of a difference of longitude was found from the probable errors of the two chronometer corrections and the probable error of the exchange of time signals.

We have then $E_{d\lambda'} = \sqrt{E^2_e + E^2_w + E^2_x}$

For the weighted mean difference of longitude of a number of nights we have

$d\lambda = \left(d\lambda_1 \frac{1}{E^2_1} + d\lambda_2 \frac{1}{E^2_2} + d\lambda_3 \frac{1}{E^2_3} + \dots \right)$ divided by $\left(\frac{1}{E^2_1} + \frac{1}{E^2_2} + \frac{1}{E^2_3} + \dots \right)$, the latter quantity representing the sum of the weights, which we may write $[p]$. From the weighted mean and the individual values of the difference of longitude we obtain a series of residuals v.

The probable error of the weighted mean is found from

$$E_0\, d\lambda = .6745 \sqrt{\frac{[p\,v\,v]}{[p]\ (n-1)}}$$

where n represents the number of individual values.

This gives then the probable error for the final difference of longitude between two successive stations.

The probable error of the longitude of a station is the square root of the sum of the squares of the probable errors of the various stations forming the chain from the prime meridian, or Greenwich, that is, $E_L = \sqrt{[E^2_0 d\lambda]}$

SYDNEY OBSERVATORY.

The following description of the instruments used at Sydney in the recent determination of the difference of longitude Sydney-Southport, has been kindly furnished by Mr. H. A. Lenehan, F.R.A.S., acting government astronomer at Sydney for New South Wales.

'The transit has a 6-inch object glass by Troughton & Simms, of London, who constructed the instrument in 1875. The focal length is 6 feet, and it is provided with a dew-cap 18 inches long.

'The bearings of the instrument are on fixed gun-metal bearings on cast-iron columns; no adjustment for corrections of level or azimuth being provided. This was designedly done, so that there would not be a possibility of alteration in any way. The eye-piece used magnifies 148 times. The instrument has two circles 2 feet in diameter, graduated to every 5 minutes of arc, and these graduations are still further

sub-divided by the micrometer microscopes, which are readily read to the tenth of a second of arc. There are two setting circles one on each side of the tube, graduated to 20 minutes of arc, and further divided by the vernier.

'Counterpoises on each pier take off the greater weight on friction wheels from the bearings, leaving very little resistance on moving in declination. A sliding reflector in the instrument regulates the illumination of the field of wires from a lamp at the end of the axis. A set of seven vertical wires and a horizontal one is provided; the equatorial intervals being about 5 seconds of time apart; and these wires are from the cocoon of one of the silk worms readily got in the gardens here. These cocoons have small sticks attached to the outer surface. We find the fibres of silk are stronger than the spider lines, and they last longer, the only drawback being their varying thickness, but this is not so marked as to cause them to be rejected.

'The instrument has a collimating telescope outside the building to the north, and reading by this (with the micrometer moving the wires) in its field, through holes in the transit circle and again through a 40-foot lens on the southern wall to a silver plate with vertical and horizontal crosses on its face. This plate is on a pier on the same level as the northern collimating telescope. We adjust the moving wires of the collimating telescope on this mark, and then take readings with the transit circle telescope on both, the mean of the adjusted wires on the northern collimator and on the southern mark gives the collimation of the transit circle, which deducting ″·010 for aberration is the final setting of the R. A. micrometer.

'Level readings are by reflection of the wires in a mercury trough on Pritchett's principle, viz., a shallow copper trough 6 inches square with an amalgamated surface containing only about 1/16 inch of mercury. This is placed in a recess below the instrument on the solid stone which carries the piers. The instrument is protected in every way from any vibrations of the building or floors, being on a separate pier extending from the bed-rock below the foundation. The observer mounted on the remover reads through a Bohnenberger eye-piece the wires covering their reflections by moving the micrometer, and the mean of these (10) readings are subtracted from the collimation, a smaller reading giving a +, a greater — sign, and expressed in the equivalent of the micrometer screw.

'Azimuth is determined by the stars by observing upper and lower transits of slow-moving circumpolar stars, and we find the instrument so extremely steady that any variation of over a fraction of a second of arc is practically not existant.

'The sidereal clock is by Frodsham, of London, and has at present a small wheel on the pendulum rod, which as it swings to the vertical presses a delicate spring into contact and marks on the chronograph for each second, omitting the 60th, thus only recording 59 beats to the minute and one break.

'A cylinder chronograph is used for observations and by diversion of current these contacts go to a tape chronograph; this is generally used with longitude. On this tape can be recorded with two pens, and can vary the beats of the clock to each pen, and the same with any signals received from longitude stations.

'The transit observations are recorded on the same chronograph as the clock by a flexible connecting wire and handle held by the observer, who presses a small spring with his thumb to make the necessary contacts recording the bisection of the star.

'The electricity is generated in four Edison-Laelande large cells, and the life of the battery is long.

'The seven wires observed are entered in the transit book and a mean taken for the central wire. This is corrected for the inequality of the divisions of the wires from the central wire, and then level and azimuth are applied, collimation being non-existing as already explained. Then follows the usual mode for arriving at the errors of the true and observed transits. The mean of these results gives the clock error at the mean time of transits. Correction for rate is applied to each star.

'The value of the wires determined from many observations of slow-moving southern stars is here given.

	s.		s.
Wire 1	15·156 from central wire	}	
2	10·176	}	+ 30·486
3	5·154	}	
4	0·000		
5	5·247	}	s.
6	10·207	}	− 30·861
7	15·407	}	
			s.
		Difference −	·375
		−	·054

BRISBANE OBSERVATORY.

The services of the observatory are essentially for time purposes. The transit is by Troughton and Simms, 1883, and is mounted on a stone pillar. The objective is of 2½ inches clear aperture and 30 inches focal length. The reversing is done by hand. The reticule has seven threads, the five central threads at equatorial intervals of about six seconds. The pivots are cylindrical and there is no inequality of pivots.

On the striding level provided, fifty-six divisions are equivalent to sixty seconds of arc.

The time-piece used for the longitude work, including personal equation, was a Kullberg sidereal chronometer, provided with a one-second electric break. The chronometer had a losing rate of about three-quarters of a second per day.

The transits and exchange of clock signals were recorded on a Morse register by embossing. The register has two styles, one always recording the clock and the other, the transit key or the time signals to or from Southport, when making exchange for difference of longitude. For the clock circuit three Leclanche cells were used, and the same number for the chronograph circuit. The telegraph line connecting Brisbane with Southport is fifty miles in length.

The following are the equatorial intervals, determined by means of the micrometer, one revolution of which = 70″·8, by Mr. T. D. Fraser.

Clamp West.

	s.
1	+23·95
2	+12·46
3	+6·12
4	+0·33
5	− 5·96
6	−12·55
7	−24·35

WELLINGTON OBSERVATORY.

The observatory was established in 1869 and is used for time service only. It is situated on the summit of the hill within the old cemetery, and overlooks the city, harbour and surrounding country. The building has two rooms, a clock-room and a transit-room.

Clocks.—In the former are three mean time clocks, and one sidereal—Dent No. 39720—having electrical attachment making contact or circuit every second except the 60th in order to identify the minute. The clocks are all mounted on brick and cement bases, and are fastened to substantial braced frames.

Transit.—The transit is by Troughton & Simms, and is mounted on a rather high stone pillar. It has an aperture of 2¾ inches, and a focal length of 32 inches. The reticule has seven threads at equal equatorial intervals of about 17 seconds of time. There is a sensitive striding level, and one oil lamp for illuminating the field. The single small setting circle reads to minutes and the reversing of the telescope is done directly by hand.

Meridian Mark.—The meridian mark, placed 35 years ago, which also serves for testing collimation in the day time, is a 3-inch iron bar set in cement, and shows well above the sky-line of the Tinakori range to the north.

Chronograph.—The chronograph is of the Morse pattern and records on a tape. It is provided with two styles, side by side. The one records, embossing by make circuit, the second-beats of the sidereal clock, while the other similarly records the signals by the transit key, also the clock or arbitrary signals received (from Doubtless Bay), when making a comparison of the clocks for the determination of the difference of longitude. The transit and arbitrary signals on the tape are readily interpolated, and expressed in time, from the embossed dots or records indicating the seconds of the local sidereal clock.

Electrical Apparatus.—Mr. J. K. Logan, Superintendent of Government Telegraphs, has furnished the following description and diagram (Fig. 6) of the arrangement especially installed at the Wellington observatory, for the differential longitude work with Doubtless Bay as this was the first time that an automatic exchange of clock signals had been made with the observatory.

The Wellington clock made contact (circuit) every second, while the chronometer at Doubtless Bay was arranged to 'break' circuit.

"Two British post office polarised relays, the coils of each of which were joined in parallel, giving a resistance of 150 ohms for each relay, were connected in multiple through three Leclanche cells to the terminals of the clock. One hundred and twenty Leclanche cells, with the copper earthed were joined to one of the local terminals of one of these relays and by adjustment, the tongue of this relay was made to bear against the stop connected to that terminal. The terminal connected with the tongue was then joined to the copper terminal of a Siemens relay of 500 ohms resistance. The line was connected to the Z (zinc) terminal of the Siemens relay through a switch arranged to disconnect it from the time recording instruments and connect it to the speaking (Morse) instruments when required.

The local terminals of the Second British P.O. polar relay were connected through 8 Leclanche cells to the terminals of the magnet coils of the back style of the chronograph. The local terminals of the Siemens' relay were connected through 8 Leclanche cells to the terminals of the magnet coils of the front style of the chronograph. At every make of the clock the tongue of the P.O. relay that was connected to the back style coils, made contact and caused the style to emboss, thus registering every clock beat. The other P.O. relay at every beat of the clock broke contact at its tongue, the line current was thus broken and a signal recorded at Doubtless Bay. As this line current passed through the Siemens' relay at the observatory, and while passing held the tongue of that relay open against the bias given to it, at every break of the current the tongue by reason of that bias, moved across and closed the local circuit, thereby recording marks on the front style.

When signals were to be received from Doubtless Bay, the observatory battery of 120 cells was cut off, battery being applied at the sending end.

At every break of the current at Doubtless Bay the Siemens' relay tongue moved to close the circuit and the breaks were recorded by the front style, marks being made at the same time by the observatory clock with the other style. Arbitraries were received from Doubtless Bay in the same way.

When arbitraries were being sent from the observatory it was arranged by means of a two-way switch, to cut off the clock from one P.O. relay, i.e., the one, the tongue

of which was in the main line circuit. This relay was then worked by the closing of a key, the line current being broken at the tongue of the relay in the same way as when the clock was operating the relay. This break was recorded at Doubtless Bay and also on the front style at Wellington by the movement of the tongue of the Siemens' relay, at the same time the clock was recording on the back style.

It is desired to indicate that for received signals the tongue of the Siemens' relay had to move to close the circuit and the front style then to move to mark the tape. The signals of the observatory clock had to cause the P.O. relay tongue to move to close the circuit and the back style then to move to mark the tape. The record of the outgoing signals either from the clock or by arbitraries was got after the clock or the key had caused the P.O. polar relay tongue to break the circuit which in turn caused the Siemens' relay tongue to move to close the circuit of the front style and which style had then to move to impress the tape.

The line was 704 miles long, Wellington to Doubtless Bay, and was of 11½ copper throughout, 200 pounds to the mile."

No repeaters were used.

DESCRIPTION OF STATIONS.

Vancouver.

At Vancouver the permanent observatory built in 1900 for longitude work was occupied. It is situated on Brockton Point, immediately to the south of the lighthouse. The transit was mounted on a brick pier and a single wire connects the observatory with the city office, distant about 3 miles, of the Canadian Pacific Telegraph system. Every night at a given time, 10.30 p.m., the observatory was put in circuit with the line to Bamfield, the terminus of the Pacific Cable, for exchange of clock signals.

Fanning Island.

This island or the group of three islands, of which it is one, was discovered by Captain Edmund Fanning on June 11, 1798.* At the time of its discovery it was uninhabited, although 'a stone case, filled with ashes, fragments of human bones, stone, shell and bone tools, various ornaments, spear and arrow heads of bone and stone, &c.,' were found.

The island is a coral atoll, about 10 miles long and 5 wide. It is only about 10 feet above the level of the ocean. The lagoon is surrounded by a fringe a quarter to half a mile in width on which is the plantation of cocoa-nut trees, for the production of the commercial article known as copra, owned by Greig brothers.

The cable station is at the northwest part of the island at Whaler Anchorage, and the observatory with pier was erected near the cable station. (See Fig. 7.)

Suva, Fiji.

The Fiji group, comprising several hundred islands, is too well known to require any further description. The two larger islands, Viti Levu and Vanua Levu, are both mountainous and have extinct volcanoes. The red volcanic soil of Taviuni, reminding one of the soil of the Hawaiian islands, is very fertile. The sea surrounding the group is studded with coral reefs dangerous to navigation. The vegetation on the islands is tropical and luxuriant. Commercially the principal products are sugar, copra and green fruits. Among other products may be mentioned the vanilla bean and trepang or bêche de mer, the latter for the Chinese market. The natives at one time the most ferocious cannibals are now docile under British rule. Bounteous nature makes them indolent, since their vocation—fighting—is gone.

Two factors militate against the development of Fiji—one is, want of labour, and the other, the difficulty of acquisition of land,—all the land, save a small part, being

*'Voyages Round the World' by Edmund Fanning; London, O. Rich, 1834.

still held by the natives and in common, so that there is great difficulty in securing land for cultivation. Suva, on Viti Levu, is the official capital, and the residence of the governor of the South Sea Islands. No military is stationed here, but a native constabulary is maintained.

The observatory (Fig. 8) was built on the Pacific Cable premises (Figs. 9 and 10). The material used in construction was planed, tongued and grooved flooring throughout. The building is ten feet square, gable roofed, and has a three-inch opening around the eaves for circulation of air. This arrangement worked very well and prevented the instrument during the day-time becoming unduly heated. There were two shutters on each side of the roof, giving a clear opening of two feet.

The pier was built of concrete. A cubic yard of concrete was sunk in the earth and the pier proper, 22 inches by 27 inches, built to a height of 30 inches above the floor of the observatory. It was learned afterwards that the ground upon which the pier was built had been filled in something over a year before to a greater depth than the excavation for the pier. This may in a measure account for the movement of the pier, although part of this motion is undoubtedly attributable to the tides. That is, the daily loading (twice) of the ocean bottom near the shore by high tide would have the tendency to tilt the pier towards the sea, which effect would later be counteracted when low tide had set in. The pier is situated 17 feet west from the cable building (verandah), 42 feet north from the south limit of the cable lot, and 11 feet from the edge of the sea at high tide.

For the pendulum observations another similar pier but only 2 feet above the floor was built within an adjoining hut, 7 feet square, to the east. The south walls of the observatory and pendulum huts were in a straight line. The floors of the two buildings were 5 feet 8 inches above high tide, so that the pendulum bob was, say, 8 feet above high tide.

The tides at Suva harbour average between 3½ to 5 feet.

For the magnetic station it was not so easy to find ideal ground. The ground has to be within reasonable distance from the observatory, to carry the instrument and chronometer to and fro.

Corrugated iron has become a most important element in building operations of the most diverse kinds in the tropics. It is used for roofs, for fences, in place of weather boards, and for many other purposes. Especially in Australia does corrugated iron meet the eye at every turn.

After examining the vacant grounds in Suva, the embryo park to the south of the cable premises was chosen for a site for the magnetic station.

The local surveyor, Mr. G. Heimbrod, who laid down a meridian for erecting the pier and observatory, also made the connection between the astronomic and magnetic stations and gave the true azimuth of some reference points from the latter. The Honourable Geo. Moore, Commissioner of Public Works, kindly placed a tent at my disposal for shelter to the instruments while observing at the magnetic station.

Norfolk Island.

Historically this isolated island (about 9,000 acres) is best remembered as a British penal colony, and later (1856) as the new home of the Pitcairn islanders, the descendants of the mutineers (1789) of the ship *Bounty*, Captain Bligh. In former days the island was the chief centre of the large whale fishing industry of the South seas. This industry has, however, much declined. The best known product of the island is the Norfolk island pine (Araucaria excelsa). An avenue of these trees is a superb sight, but in the individual tree the branches are rather too far apart to give it a finished symmetry and beauty.

The cable lands at Anson bay at the northwestern part of the island, and the cable buildings are in close proximity to the precipitous cliffs of the shore. The observatory with pier was erected between the cable buildings and connected in dis-

tance and azimuth to a stone monument as shown on the accompanying diagram (Fig. 11).

Southport.

The observatory built here was erected 30 feet southerly from the brick pillar supporting the water tank near the south entrance to the offices of the cable building. The magnetic station was in the vacant field of the cable premises and 186 feet southward from the astronomic station (Fig. 12). The observatory was 10 feet square and built similar to the one at Suva already described. For foundation of the pier a cube of grouting was built in the earth, leaving its sides free from firm contact with the earth. The pier 22 inches by 27 inches itself was built of brick with an inch cap of concrete.

The alignment for the pier and observatory was obtained without the aid of instruments by low north and south stars and a plummet, sidereal time having been deduced from the noon mean time signal from the observatory at Brisbane.

At this station, connection was made with the observatories at Brisbane and Sydney; and for this purpose, the land line in the cable office was led to the observatory so that the clock and arbitrary signals during the nightly exchange with those observatories could be recorded on the chronograph.

The route line distance to Brisbane was 50 miles, and to Sydney, 773 miles. The conductor was of copper, weighing 200 lbs. to the mile. The line was cut through to Sydney direct during the exchange, that is, no relay was interposed between the terminal stations.

Doubtless Bay, N.Z.

At the foot of the deep bay of the above name the cable from Norfolk island lands on a sandy beach. Close to the cable station the pier and observatory were built (Fig. 13). The foundation of the brick pier was in compact sand, and hence very satisfactory. The building and pier were of the same dimensions as those of Southport and Suva.

A triangulation has been carried over the North island by the Survey Department of New Zealand. By instruction of the Surveyor General, Mr. J. W. A. Marchant, the district surveyor, Mr. V. J. Blake, made a connection of the triangulation system with the observatory, pendulum pier and magnetic station, as shown on the accompanying sketch (Fig. 14).

The country about the station is open and hilly. Much of the ground is covered with ti-tree scrub, and in the valleys the tree fern, cabbage tree and the kauri pine are found. Near the sea-coast on rocky exposures scattered pohutukawas, or Christmas trees, with their beautiful, large, red flowers and glossy leaves are seen. The English name of the tree was given because it flowers at that season.

The rocks observed were strongly impregnated with iron.

AUSTRALIAN LONGITUDES.

Former Values.

Australia.

The transit of Venus in 1874 gave an impetus to the determination of longitudes. Some of these longitudes were determined by means of the telegraphic submarine cables, while others were dependent upon absolute methods,—moon culminations and occultations.

To the latter belonged Sydney. Consequent to the German Venus expedition to the Auckland islands, Dr. A. Auwers recomputed the voluminous data (mostly from Mr. Tebbutt and Mr. Russell) on hand for the longitude of Sydney, through which he laid the fundamental meridian for Australia.

This gives the longitude of Sydney as $10^{h.}\ 04^{m.}\ 49^{s}{\cdot}60$.*

* Astron. Nach. No. 2036.

In the joint report † of the government astronomers, Ellery, Todd and Russell we read: 'Some time prior to the transit of Venus, in December, 1882, we severally received communications from the President of the Royal Society, London, relative to the telegraphic determination of the longitude of Australian observatories, which involved, as a first step, the telegraphic determination of the difference of longitude between Port Darwin and Singapore . . . . . . Singapore being the initial point of these determinations, the actual longitude of Port Darwin and hence all Australian longitudes would depend on the accuracy of the assumed longitude of Singapore, which has twice been telegraphically determined—first, in 1871, by Dr. Oudemans, of Batavia, and Mr. Pogson, of Madras, and more recently, in 1882, by Commander Green, United States Hydrographic Department. For reasons given in the appendix, we agreed, after full consideration, to accept Commander Green's position of Flagstaff at Fort Canning, viz., $6^{h.}\ 55^{m.}\ 23^{s}\cdot50$. Reducing this to Captain Darwin's observing station $+1^{s}\cdot51$, makes the longitude of Captain Darwin's transit instrument $6^{h.}\ 55^{m.}\ 25^{s}\cdot01$. The difference of longitude, Port Darwin-Singapore, determined by Captain Darwin and Mr. Baracchi, is $1^{h.}\ 47^{m.}\ 57^{s}\cdot48$, making the longitude of Port Darwin $8^{h.}\ 43^{m.}\ 22^{s}\cdot49$ E. of Greenwich.'

The station at Port Darwin was marked by a masonry pillar 4 x 2 x 2 feet, upon which the transit stood, and is the origin of Australian longitudes.

By means of the telegraph lines Port Darwin, Adelaide, Melbourne and Sydney were connected in longitude, and similarly by cable Melbourne with Hobart, and Sydney with Wellington, New Zealand. It must be remembered that up to this time in most cases, when the cable was used for the exchange and comparison of clock signals, the small deflecting mirror, throwing a beam of light on a scale, indicated the arrival of the signal impulse. This visual manifestation had then to be recorded in time, either by the 'eye and ear' method or by tapping a key in circuit with a chronometer and chronograph. Comparison of chronometers over a cable by this means has not nor cannot have that accuracy obtained in more recent times by the exclusive use of the Thomson (Lord Kelvin) siphon recorder, to be described later. In the Bombay-Aden-Suez, 1877 longitude, the siphon was used.

In order to estimate the value of Australian longitudes it is necessary to examine the assumed position of Singapore upon which those longitudes rest.

Mr. P. Baracchi, who was the observer at Port Darwin, and is now Government Astronomer, at Melbourne, for Victoria, presented a paper on 'The most Probable Value and Error of Australian Longitudes' to the Australasian Association for the Advancement of Science, at the meeting in Brisbane in 1895.

Mr. Baracchi has expended much labour in compiling from so many sources the required data, and has put the results in such compact form, that I avail myself in reproducing the greater part of it here. He always gives the 'mean error' instead of the 'probable error' as is customary in our work. The former is readily converted to the latter by simply multiplying it by ·675.

He writes:—I shall therefore commence at the beginning, viz., the prime meridian. The values of intervals, as given in Appendix, Table 1, will be referred to by the letters respectively attached to them.

Longitude of Alexandria—Six different values—viz., (*a*), (*b*), (*c*), (*d*), (*e*) and $\frac{1}{2}(f+f_1)$—may be combined, giving three values for this longitude, two of which are quite independent.

(*a*) *Greenwich-Mokattam.*—This was determined by exchange of galvanic signals between Greenwich and Porthcurno; Porthcurno and Alexandria (by joining the five lengths of cable, Porthcurno, Vigo, Lisbon, Gibralter, Malta, Alexandria); and finally, between Alexandria and Mokattam. Time observations were made with transit instruments at Greenwich, Alexandria, and Mokattam, but those at Alexandria were not used for this interval. The observers were Mr. Criswick at Greenwich, Mr. Ellis

† Report of the Telegraphic Determination of Australian Longitudes—Melbourne, 1886.

at Porthcurno, Mr. S. Hunter at Alexandria, and Capt. C. Orde Brown, R.A., at Mokattam. Transits were recorded by eye and ear at these two latter places. All galvanic signals were sent by hand, and observed by eye and ear. The operations were executed in November, 1874, on the four nights, 14th, 15th, 21st and 22nd. The personal equation in observing transits between Mr. Criswick and Capt. Brown was determined before and after the longitude operations, and varied from 0·025 sec. to 0·655 sec.—(8) page 288.

(*b*) *Alexandria-Mokattam.*—(8) On the same four nights, November 14, 15, 21 and 22, Mr. Hunter, at Alexandria, made transit observations with a portable transit instrument, in addition to exchange of signals with Mokattam. His station, which was on the roof of the Hotel de l'Europe, does not seem to have offered the necessary stability for delicate work. Dr. Gill remarks of this station—(7) page 63—'The observer had to abstain from movement during each complete observation, otherwise the level was disturbed by the change of his position.' The personal equation of the two observers was determined after their return to England. At Alexandria the chronometer had to be carried to the telegraph office for exchange of signals, which was at a distance of about five minutes' walk.

(*c*) *Greenwich-Berlin.*—Result of several determinations—(9) page 490.

(*d*) *Berlin-Malta.*—Observers: At Malta, Dr. Löw, chief of the German expedition of the Transit of Venus, 1874, to Mauritius; at Berlin, the astronomers of the observatory, Drs. Becker, Auwers and Knorre. Dr. Löw made time observations with a portable transit instrument, recording by the eye and ear. Galvanic signals exchanged by hand on six nights in 1875, March 10, 11, 12, 13, 14 and 15. Personal equation well determined. Signals satisfactory—(9) page 360-393.

(*e*) *Malta-Alexandria.*—Observers: Dr. Löw at Malta, Dr. Gill at Alexandria, same station as Mr. Hunter's. Dr. Gill made his time determinations with an altazimuth. Operations repeated on the nights of March 10, 11, 12, 13 and 14 (1875). Personal equation of these observers well determined.

The chronometers had to be carried to the telegraph station for exchange of signals, as in the case of (*b*)—(9) page 306-320.

(*f*) *Berlin-Alexandria.*—Direct measurement made on February 28, March 6, 7, 10, 12, 13 and 14 (1875). Personal equations of the observers, known through Dr. Löw; the observers being Dr. Gill at Alexandria, and the astronomers of the observatory at Berlin. This value was deduced by Dr. Copeland. It is remarked in (9) that the signals were unsatisfactory, and the combination of the two intervals (*d*) and (*e*) was adopted in preference of the direct value—(9) page 320-348.

(f_1) *Berlin-Alexandria.*—Same operations as in (*f*). Value deduced by Dr. Auwers—(7) page 60.

The three values for the longitude of Alexandria are:—

	h.	m.	sec.
By the combination (*a*)–(*b*)	1	59	33·69
(*c*)+(*d*)+(*e*)	1	59	33·827
(*c*)+½ [(*f*)+(f_1)]	1	59	33·750

The following values were adopted, viz.:—

(9) Page 491—
By Dr. Copeland. . . . 1h. 59m. 33s·807
(7) Page 60—
By Dr. Auwers. . . . 1h. 59m. 33s·885
mean 1h. 59m. 33s·846 ± 0s·078 (Mean error.) I.

(8) Page 330—
By British Transit of Venus Expedition. 1h. 59m. 33s·69 ± 0s·156 II.

The values I. and II. of the longitude of Alexandria are independent. Their difference is 0·156 seconds.

(*g*) *Alexandria-Suez.*—Observers: Dr. Löw at Suez, Dr. Gill at Alexandria. Instruments for time determination, same as already stated above. Galvanic signals

exchanged on five nights, viz., 1875. February 19, 20, 23, 24 and 25. Signals sent by hand; observations made by eye and ear. At both stations the chronometers had to be carried for some distance to exchange signals. Result computed by Dr. Copeland—(9) page 492.

(g_1) *Alexandria-Suez.*—Same operations as in (g). Result deduced by Dr. Auwers—(7) page 60.

(h) *Mokattam-Suez.*—Observers: Mr. Hunter at Suez, Captain Brown at Mokattam. The instruments used by these observers have already been referred to in (a) and (b). The signals were sent by hand, and the observations made by eye and ear. Operations repeated on four nights, viz., 1874, December 4, 5, 7 and 14. The station used by Mr. Hunter was not the same as Dr. Löw's station. The former appears to have given trouble on account of its instability. It is remarked by Mr. Hunter—(8) page 333—'The only defect arose from the looseness of the soil, causing the level readings to vary a good deal.' The same complaint is also made by the officers of the Great Trigonometrical Survey of India, who used this station in 1877, viz., that their observations may be somewhat vitiated by the unsteadiness of their instruments, due to looseness of the soil—(12) page 45*a*.

(i.) Difference of longitude between Dr. Löw's and Mr. Hunter's stations at Suez.

This was determined by Dr. Gill by time observations made by himself with Dr. Löw's transit instrument mounted at one station, and with his altazimuth mounted at the other station, and by transportation of nine chronometers to and fro. The value thus found was 0·32 seconds—(9) page 262-266.

(i_1) The same interval as (i), determined by a traverse under the direction of Captain (now Colonel) Campbell, R.E.; its value was found to be 0·025 seconds—(9) page 491 and (11) Appendix to Part II., page 109. The discordance between the two above values is 0·295 seconds. This may be probably accounted for, or at least partly, by the length and complex character of Dr. Gill's operations, when compared with a simple traverse; and also by the circumstance remarked in (9) page 262, that 'these operations required seven and a-half hours of continuous observing, involving great fatigue.'

We have thus the two following independent values for the interval Alexandria-Suez, reduced to Hunter's station, by adopting value (i_1), viz.:—

	h.	m.	sec.	sec.
$\frac{1}{2}\{(g)+(g_1)\}+i_1$	0	10	39·025	± 0·082
$(b)+(h)$	0	10	39·481	± 0·160

which differ by 0·456$^{sec.}$

The value for Alexandria-Suez, deduced from the two above, weighted in terms of their respective mean error, is—

	h.	m.	sec.	sec.
Interval Alexandria-Suez.	0	10	39·120	± 0·073. . .III.

(k) *Suez-Aden.*—Observers: Dr. Löw at Suez, Dr. Gill at Aden. Time observations at Aden were made with some difficulty; in fact, 'opportunities for observing were few and unsatisfactory'—(9) page 5. At Aden, the distance between the observing station and the telegraph office where signals were sent and received was nearly two miles. The operations were very limited, and the result depends on time observations of the single night of January 31, and on the exchange of galvanic signals on the two nights of January 30 and 31. This result was computed by Dr. Copeland—(9) pages 196-227.

(k_1) *Suez-Aden.*—Same operations as in (k). Result given by Dr. Auwers—(7) page 61.

(k_{11}) *Suez-Aden.*—Observers: Captain (now Colonel) Campbell, R.E., at Suez; Captain (now Colonel) Heaviside, R.E., at Aden. Station at Suez the same as Mr. Hunter's. Station at Aden, a few yards north of the cable offices at Telegraph Bay.

These officers aimed at the highest refinement possible, and had at their disposal the necessary equipment and conveniences wherewith to attain their purpose—(11), Part I., Chapter I. Their transit instruments were of similar dimensions and workmanship (5″ object glass, with collimators, and means of levelling by mercury reflection, &c.). They recorded observations by chronograph. Galvanic signals were always exchanged directly between the stations, being sent by hand, and simultaneously recorded on both chronographs. Their operations were repeated on the six nights of 1877, May 25, 26, 27, 28, 29, and 30, giving very accordant results. Their personal equation was determined on four nights in April, 1877; and although it was not redetermined after the expedition, no serious consequences may be feared on that account. The observers themselves are confident that it remained fairly constant—(11), Part I., page 34. On the other hand, if their usual mode of observing was liable to sudden changes of considerable magnitude (of which there is no evidence), a redetermination after the expedition would have given very little help in finding the actual changes that took place at Suez and Aden. The only disadvantage in this measurement is to be attributed to the unsteadiness of the station at Suez, as already pointed out in (*h*)—(11), Part II.

(*l*) Difference of longitude between Dr. Gill's and Captain Heaviside's station at Aden.

This was determined by a careful triangulation, made under the direction of Captain Heaviside—(11) App., Part II.

We have, then, for the interval Suez-Aden reduced to Mr. Hunter's station at Suez, and Captain Heaviside's at Aden—

	h.	m.	sec.	sec.
$\frac{1}{2}\{(k)+(k_1)\}-i_1-l$	0	49	42·839	± 0·120
(k_{11})	0	49	42·662	± 0·060

The difference between these two independent results is 0·177 sec. Combining them according to their mean errors, we have—

	h.	m.	sec.	sec.	
Suez-Aden	0	49	42·697	± 0·054	IV.

The longitude of Aden, reduced to Captain Heaviside's longitude station, may now be derived by combining the several values shown in the foregoing, in the manner adopted by Dr. Gill—(7) pp. 60-62—omitting the value given for Alexandria-Mokattam, viz.:—

By the British Transit of Venus Expedition of 1874, and the officers of the G. T. S. of India.

	h.	m.	sec.	sec.
(*a*)	2	05	06·240	± 0·098
(*h*)	0	05	06·931	± 0·103
(k_{11})	0	49	42·662	± 0·060
A	2	59	55·833	± 0·154

By Lord Lindsay's Expedition of 1874, and Dr. Löw.

	h.	m.	sec.	sec.
I	1	59	33·846	± 0·078
$\frac{1}{2}\{(g)+(g_1)\}$	0	10	39·000	± 0·082
$\frac{1}{2}\{(k)+(k_1)\}$	0	49	43·742	± 0·120
(*l*)	—0	00	00·877	± 0·
B	2	59	55·711	± 0·165

	h.	m.	sec.	sec.
A	2	59	55·833	± 0·154
B	2	59	55·711	± 0·165
Longitude of Aden (Capt. Heaviside's sta.)	2	59	55·776	± 0·113

Dr. Gill considered the mean errors of the two values A and B as equal, and adopted for the definitive longitude of Aden $\frac{1}{2}$ (A + B) (7) p. 62, viz.:—

Aden E. of Greenwich $2^{h.}$ $59^{m.}$ $55^{s}{\cdot}772 \pm 0{\cdot}079^{sec.}$ (should be $0{\cdot}076^{sec.}$?)

(*m*) *Aden-Bombay.*—Observer: Dr. Gill at Aden (Gill's station). The operations at Bombay were conducted under the direction of Mr. C. Chambers, Superintendent of the Colaba Observatory. Time at Bombay was determined by a transit instrument 5 feet focal length. Records made by chronograph. Time signals sent by hand, and observed by eye and ear at both stations. These operations took place in 1875, on 31st January, concurrently with the determination Suez-Aden by Drs. Gill and Löw; the time observations of this single night being all that could be secured at Aden. The personal equation between the observers not determined—(9) pages 182-195.

(m_1) *Aden-Bombay.*—Observers: Captain Campbell at Aden, and Captain Heaviside at Bombay. This measurement was made with the same instruments and methods described in (k_{11}). The station at Aden was the same as that occupied by Captain Heaviside in determining the interval (k_{11}). That at Bombay was $0{\cdot}134^{sec.}$ east of the Colaba Observatory transit instrument. The operations were repeated on nine nights in 1877—April 30, May 1, 2, 3, 4, 5, 7, 8, and 9—giving accordant results.

The two values (*m*) and (m_1) are quite independent. The former is based on observations and conditions not altogether satisfactory (as we have seen), with very limited time and great disadvantages, and involving the unknown element of the personal equation of the observers. The latter value (m_1) is the result of elaborate operations extending over a period of nine nights, and made under the best possible conditions; yet these two results differ only by $0{\cdot}03^{sec.}$

(*n*) *Bombay.*—Difference of longitude between Captain Heaviside's station and the transit instrument of the Colaba Observatory. This was determined by a traverse measured under the direction of Captain Heaviside (11).

(*o*) *Bombay-Madras.*—Observers: Captains Campbell and Heaviside. Station at Bombay the same as that used for the interval (m_1). That at Madras was 65 feet due north of the transit circle of the Madras Government Observatory. This interval, though not determined directly, is certainly as well ascertained as any other—(11), Part I.

Its value is deduced from the telegraphic measurement of the difference of longitude of nine Indian arcs joining the six stations—Bombay, Bolarum, Bellary, Mangalore, Vizagapatam, Madras; the most direct route being Bombay-Bellary-Madras. (See diagram in (11) Part I., page 16.) The operations were executed by these officers in 1875-76-77 through the land lines, using the same instruments as mentioned in (k_{11}). Time signals were exchanged automatically, and simultaneously recorded at the two stations. Every possible precaution was taken to guard against error, systematic or accidental, and the work generally was carried out with a completeness that leaves nothing to be desired. The result for this interval is shown in (11) Preface to, Part I., page (xviii.).

We are now enabled to deduce the longitude of Madras; but before doing so, I shall mention and consider another set of totally independent operations, which must be regarded as a powerful check upon all others hitherto discussed—viz., the determination of the longitude of Madras, via Ispahan-Kurrachee. Indeed, if it were not for the very limited and somewhat incomplete observations at Kurrachee, and the undetermined personal equation of the observers at Ispahan and Madras, this chain would be entitled to much greater weight than the one via Suez-Aden-Bombay, because it connects Madras with Greenwich in four steps including only five stations, three of which are fixed national observatories, in addition to having the interval Kurrachee-Madras measured twice independently. I regret that, with the exception of the operations at Madras and Kurrachee, the details of the observations are not at hand; the

results given here being taken from General Addison's paper—(10) page 83, and (13) pages 47, 54, 81. The actually measured intervals are as follow:—

(p) *Berlin-Ispahan.*—Observers: The astronomers of the Berlin Observatory, at Berlin; and Dr. Fritsch, chief of German Transit of Venus Expedition in Persia (1874), at Ispahan. The operations were repeated on eight nights—viz., November 16, 17, 18, 19, 20, 21, 23 and 27.

(q) *Ispahan-Kurrachee.*—Observers: Dr. Fritsch at Ispahan, and General T. Addison, C.B., at Kurrachee. General Addison observed for time with a portable transit instrument, and recorded his observations as well as galvanic signals by chronograph. Signals were exchanged on December 11 and 12, 1874. Personal equation between the observers not determined—(10) page 83.

(r) *Kurrachee-Madras.*—General Addison at Kurrachee, and Mr. Norman Pogson, Government Astronomer, at Madras. Galvanic signals were exchanged on one night only—viz., December 13. The time at Kurrachee depends on the observation of three stars. Results given by General Addison—(10) page 83.

(r_1) *Kurrachee-Madras.*—Same operations as in (r); value deduced by Mr. Pogson—(13) pages 47, 54, 81.

(r_{11}) *Kurrachee-Madras.*—This interval was determined indirectly through Bombay and Bellary and other Indian arcs by Captains Campbell and Heaviside in their usual excellent manner, as already spoken of. The operations were executed in 1880-81.

(s) Difference of longitude between General Addison's and Captain Campbell's station. The position of the former was 0·6$^{sec.}$ east of the station 'used in the Great Trigonometrical Survey at that place'—(10) page 84. The position of the latter is described in (11) Part I., page 252, as being 61 feet north, and 152 feet =1″·65= 0·11$^{sec.}$ west of the 'Telegraph Office Station,' which is a point 'on the eastern terrace of the upper story of the block of dwelling quarters standing in the angle between Macleod road and Telegraph road, marked by a circle and dot engraved on the floor of the terrace, and connected with the Hill Stations A and Mutrani of the G. T. S.' It seems, therefore, that the 'Telegraph Office Station' is the one referred to by General Addison as being 0·6$^{sec.}$ west of his observatory.

We may now compare the three values (r), (r_1), (r_{11}) of the interval Kurrachee-Madras, reducing them all to the Telegraph Office Station of the Great Trigonometrical Survey.

	sec.	h.	m.	sec.
(r)	+ 0·60 =	0	53	06·82
(r_1)	+ 0·60 =	0	53	06·45
(r_{11})	− 0·11 =	0	52	55·61

The two values (r) and (r_1) are derived from the same few and simple observations of a single night. Their difference is 0·37$^{sec.}$ and has not been accounted for by the astronomers concerned. The value (r_{11}) is 11·21$^{sec.}$ smaller than (r), and 10·84$^{sec.}$ smaller than (r_1). This large error was pointed out in (6), page 31. No doubt some clerical mistake occurred somewhere, or the position of General Addison's station may be misunderstood; but to assume that this is a clerical error of ten seconds so as to make it a round number, as Mr. Pogson proposes—(13) page 81—seems arbitrary. It is strange that in all these years we have never heard an explanation of this matter.

The longitude of Madras is thus arrived at by two routes, as follows:—

Via Suez-Aden-Bombay.

	h.	m.	sec.	sec.
Longitude of Aden (Gill)	2	59	55·772 ±	0·113
Aden-Bombay (m_1)	1	51	19·973 ±	0·056
Bombay-Madras (o)	0	29	43·530 ±	0·058
Longitude of Madras, VI	5	20	59·275 ±	0·139

Via Iśpahan-Kurrachee.

	h.	m.	sec.
(c)	0	53	34·865
(p)	2	33	05·44
(q)	1	01	13·09
$\frac{1}{2}\{(r) + (r_1)\}$	0	53	06·035
Longitude of Madras	5	20	59·430 . . . VII.

It would appear from result VII. that the error at Kurrachee vanishes in the sum of the two intervals Ispahan-Kurrachee and Madras-Kurrachee; in which case the results VI. and VII. compare very well indeed, considering that the unknown personal equation (Fritsch-Pogson) is involved in VII. I think, however, that this latter value may not be used for any further purposes at present. It would be difficult to do proper justice to it, even if favourable assumptions were made, which is always a dangerous course.

(t) *Madras-Singapore.*—Observers: Dr. J. A. C. Oudemans, Surveyor-General of Java, at Singapore; Mr. Pogson, at Madras. This measurement was made in July, 1871, by the exchange of galvanic signals, through the cable, on the evenings of 24th, 25th, 26th and 28th. Mr. Pogson observed with the transit circle of the observatory and clock, but had to carry a mean time chronometer to the cable offices for exchange of signals at a distance of four miles. Dr. Oudemans made his time determinations on the 24th by observing zenith distances of two stars with a universal instrument. On the 25th and following dates the observations were made with a 'broken transit instrument'—viz., one of the form in which the eyepiece is at one end of the horizontal axis. He also had to carry his chronometer to the cable offices for exchange of signals at a distance of three-quarters of a mile. Observations at both stations were made by eye and ear, no chronographs being used. The personal equation of the observers was not determined—(13) page 11, and (15) page 69. The point to which Dr. Oudemans referred his longitude was the position of the flagstaff on Fort Canning in 1871—see (15) page 69, and (14) page 211.

This result was deduced by Dr. Oudemans—(14) page 214.

(t_1) *Madras-Singapore.*—Same operations as in (t). Result given by Mr. Pogson—(13) pages 11-24.

(t_{11}) *Madras-Singapore.*—This determination was made by Lieut. Commander C. M. Davis, U.S.N., at Madras, and Lieut. John A. Norris, U.S.N., at Singapore, in 1882; the operations being repeated on the five nights of January 20, 21, 23, 26, and 27. These officers made their time observations with the so-called 'broken transit instruments,' which offer the great advantage that the observer remains in the same position during observations of stars at all altitudes—a condition greatly favouring the constancy of personal equation. They exchanged galvanic signals directly from their huts, thus avoiding the danger of having their chronometer rates accidentally disturbed, and errors of comparison. They had chronographs upon which their observations were recorded, and their personal equation was continuously tested by 'absolute personal equation instruments,' each observer being provided with one. This equation, however, was not introduced in the results, on account of its being always very small, and probably no greater than its possible variations. Cable signals were observed by reflecting galvanometers. The observers were especially well trained for that class of work, having made together many longitude determinations in various parts of the world. Their plans were all prearranged and methodically carried out,

and the excellence of their results is shown in the agreement of values deduced from each night's observations. The discrepancy between the values (t) and (t_{11}) is 0·71 seconds, and that between (t_1) and (t_{11}) is 0·51 seconds. The Australian astronomers, in their report—(6) page 31—adopted the value (t_{11}), which course, considering the circumstances surrounding the two determinations of this interval, was no doubt the best.

(u) *Singapore to Port Darwin.*—This interval was determined in 1883, the observers being Captain (now Major) L. Darwin, R.E., at Singapore, and myself at Port Darwin. Captain Darwin made his time observations with the transit instrument previously used by the British Expedition of the Transit of Venus in New Zealand in 1882, and I observed with an excellent portable transit instrument (3½ inches object glass). The observations were recorded by chronograph. Galvanic signals were exchanged directly between the stations, sent by hand, and observed by reflecting galvanometer at each receiving observatory. Our personal equation was determined before the undertaking at Melbourne, and experiments were made at Melbourne and Sydney to test our mode of observing and transmitting signals. Three different methods were used in exchanging signals, in accordance with a plan proposed by Captain Darwin, which was strictly adhered to throughout. This plan is described in (6) page 26. The operations were repeated on the nights of February 13, 14, 15, 22, 23, 25, and 26.

The two cable lengths Singapore-Banjoewangie and Banjoewangie to Port Darwin were joined; and the signals, though passing through a distance of over 2,000 miles, were satisfactory when the circuit was good. On some occasions they appeared unsteady; but the greater attention then required in observing them seemed to compensate for their inferior quality, as the individual results show.

(v) Difference of longitude between the flagstaff on Fort Canning (position of 1871) and Lieut. Norris' station at Singapore in 1882. This latter is the same as that occupied by Captain L. Darwin in 1883. This value is given in (15) page 68, and was determined by measurement by Lieut. Norris. The flagstaff was west of Lieut. Norris' station. My station at Port Darwin was on the ground of the Eastern Extension Telegraph Company, 56 feet N. 40·22° E. of the veranda post at the northeast corner of the cable officer's quarters. It was marked by a masonry pillar 4 x 2 x 2 feet, upon which the transit instrument stood. This point is now the origin of the Australian longitudes (6).

(w) *Singapore-Banjoewangie.*—Observers: Captain Darwin at Singapore, and Captain H. Helb of the general staff, Batavia, at Banjoewangie. Captain Helb made his time determinations by observing zenith distances with a portable universal instrument. Galvanic signals were exchanged on February 17, 18, 19, 21, and 23, 1883. The personal equation between the observers was not determined—(6) page 29.

(w_1) *Banjoewangie to Port Darwin.*—This interval was determined by Captain Helb and myself. Signals were exchanged on four nights—viz., January 28, February 1, 22, and 23, 1883. Personal equation between the observers not known.

These operations were arranged at the request of the Dutch Government in order to verify the longitudes of Batavia. We were glad to have Captain Helb's co-operation, as it was not certain whether the direct signals between Singapore and Australia would be good enough for the purpose, and also as a check to our work. Captain Helb shortly after sent all his observations in detail over to Melbourne, where they were found in every respect excellent.

The two values (w) and (w_1) offer a partly independent value of the interval Port Darwin to Singapore, although the Banjoewangie longitude itself remains affected by the unknown personal equation of H. D. and B. The difference between the direct value (u) and the indirect one (w) + (w_1) is as follows, viz.:—

	h.	m.	sec.	sec.
(w)	0	42	06·78	± 0·076
(w_1)	1	05	50·84	± 0·091
	1	47	57·62	
Personal equation (D.B.)			·02	

	h.	m.	sec.	sec.	
Singapore to Port Darwin (indirect)	1	47	57·60	± 0·119	Difference
Singapore to Port Darwin (direct) (u)	1	47	57·48	± 0·046	0·12sec.

These combined in terms of their mean errors give:—

Singapore (Captain Darwin's station)—

	h.	m.	sec.	sec.	
Port Darwin	1	47	57·49	± 0·045	VIII.

The longitude of Port Darwin may now be deduced, viz.:—

	h.	m.	sec.	sec.
Longitude of Madras (VI.)	5	20	59·275	± 0·139
Madras to Singapore (t_{11})	1	34	24·07	± 0·040
(v)			1·51	±
Singapore to Port Darwin (VIII.)	1	47	57·49	± 0·045
Longitude of Port Darwin (IX.)	8	43	22·34	± 0·152

(x) *Port Darwin to Adelaide.*—Observers: Mr. (now Sir Charles) Todd at Adelaide, and myself at Port Darwin. The observations at Adelaide were made with the transit instrument of the observatory. The exchange of galvanic signals here consisted in sending clock-beats to each other automatically (generally two sets of two minutes each), which were simultaneously recorded on the chronographs at the two stations, the chronograph of the receiving station recording at the same time the beats of its own clock. The personal equation between the observers was determined on several occasions through Mr. E. J. White, then Chief Assistant at the Melbourne Observatory, and directly in Melbourne. The operations were repeated on six nights—viz., February 14, 15, 22, 23, and 26, and March 2, 1883—(6) page 22.

(y) *Melbourne-Adelaide.*—The operations for this interval were carried out at the two observatories under the direction of their respective government astronomers, Mr. Ellery and Mr. Todd. The observations were made by the latter at Adelaide, and by Mr. E. J. White at Melbourne. Clock-beats (generally two sets of two minutes each) were exchanged, and simultaneously recorded on the chronograph of both stations, &c., as in the case of the interval (x), Port Darwin to Adelaide. Personal equation between Messrs. Todd and White was determined several times. Comparisons made on five nights—viz., February 15, 17, 23, 26, and March 2 (1883).

(x_1) *Port Darwin to Melbourne.*—Observers: Mr. E. J. White at Melbourne, and myself at Port Darwin. The operations were exactly similar to those described in the two preceding intervals. Time signals were exchanged on four nights—viz., February 15, 23, 26, and March 2 (1883), the individual results being very fairly accordant. The personal equation between the observers was determined before and after the expedition—(6) page 22.

The value (x_1) ought to be equivalent to the sum of (x) and (y).

We have, in fact—

	h.	m.	sec.	sec.
Adelaide to Port Darwin (x)	0	30	57·80	± 0·041
Melbourne to Adelaide (y)	0	25	33·84	± 0·050
Melbourne to Port Darwin, indirect	0	56	31·64	
Melbourne to Port Darwin (x_1), direct	0	56	31·66	± 0·044

(z) *Sydney-Melbourne.*—This interval was measured five times by direct connection of the observatories between the years 1861 and 1884. The operations consisted, as usual, in the automatic exchange of clock-beats, producing chronographic records at the two observatories, and in time determinations made with the transit circles of these institutions, the whole under the direction of the respective government astronomers. An indirect determination was made in 1868 through the longitude station at the western boundary of Victoria, of which more hereafter.

The last indirect measurement took place in 1887, through Mr. John Tebbutt, private observatory at Windsor, New South Wales. Mr. Tebbutt made his time determinations with a small transit instrument; sent his signals by hand from the local telegraph office, which is at a distance of (?) miles from his observatory, using a mean time chronometer, and observing the incoming signals by coincidence of beat. His operations were conducted with great care, and gave very satisfactory results.

The astronomers at Melbourne give great weight to the value of 1861, and to those of May and August, 1884. The mean of the five independent values is $24^{m.}\ 55{\cdot}408^{sec.}$ The mean of the last two is $24^{m.}\ 55{\cdot}395^{sec.}$, and that of 1861 is $24^{m.}\ 55{\cdot}38^{sec.}$ The value $24^{m.}\ 55{\cdot}40^{sec.}$ was adopted in (6) page 24 as the most probable. We may now conclude the longitudes of the three principal observatories east of Greenwich on the evidence of the telegraphic method alone, as follows, viz.:—

	h.	m.	sec.	sec.
Longitude of Port Darwin, IX..	8	43	22·34	± 0·152
Port Darwin to Adelaide Observatory (x)..	0	30	57·80	± 0·041
Longitude of Adelaide Observatory, X.. ..	9	14	20·14	± 0·157
Melbourne-Adelaide (y)..	0	25	33·84	± 0·050
Longitude of Melbourne Observatory... ..	9	39	53·98	± 0·165
Longitude of Port Darwin, IX..	8	43	22·34	± 0·152
Melbourne to Port Darwin (x_1)..	0	56	31·65	± 0·044
Longitude of Melbourne Observatory, XI..	9	39	53·99	± 0·158
Sydney-Melbourne (z)..	0	24	55·40	± 0·091
Longitude of Sydney Observatory, XII....	10	04	49·39	± 0·182

Probable amount of Uncertainty of the Australian Longitudes.

It remains now to be seen with what degree of confidence the given results may be taken.

The theoretical errors attached to the longitudes of Adelaide, Melbourne and Sydney, found above, are respectively $\pm 0{\cdot}157^{sec.}$, $\pm 0{\cdot}158^{sec.}$, and $\pm 0{\cdot}182^{sec.}$ It has already been stated that these errors represent only that part of the probable uncertainty due to the disagreement of separate results of the same measure derived from each night's work, when compared with their mean value. It would appear then that the really and purely accidental errors incurred in each single night of the period upon which a longitude result depends are fairly measured by the theoretical errors; or, if this measure is not quite satisfactory, is at least the best that can be obtained. But there may be involved systematic errors common to all the nights of that period, some of which are beyond the reach of investigation, and others that might possibly be discovered only by delicate and continued experiments in fixed institutions, but not in the temporarily arranged longitude observatories.

Altered personal equations at each new place of observation, instrumental changes, flexure, physical peculiarities of the localities, and many other known and unknown causes may bring in systematic errors not easily discovered. The theoretical error has no concern in these matters, and gives no help. It is when new instruments and new observers are employed in different years, so as to make the redeterminations entirely independent, that the existence of these systematic errors is revealed, if the results do not agree. But even then it is difficult, if not sometimes impossible, to

locate them. There are, besides, inaccuracies the causes of which are traceable, such as unsteadiness of stations, imperfect adjustment of electric instruments, changeable strength of circuits, level imperfections, unfavourable conditions such as having to carry time pieces to a distance, and others; but their effect can only be made evident by new measurements.

Every determination of differential longitude, however short the interval may be. is weakened by at least some of the causes here enumerated.

Admitting consummate skill in the great majority of the observers concerned, we may then look at the conditions under which this long longitude chain, Greenwich-Australia was developed, in order to see where its deficiency in strength is more especially to be feared.

There appears to be at first a natural division at Aden. The three intervals on the western portion were all measured twice, the results giving, as we have seen, the following discordances:—

	sec.
Greenwich-Alexandria	0·156
Alexandria-Suez	0·456
Suez-Aden	0·177

Indeed, remembering the circumstances, these differences seem very small. Yet, although the aggregate error in the Aden longitude may not be more than one-fifth of their sum, it would not be unreasonable to suspect that it may amount to half a second of time or even more, for the unsteadiness of the stations at Alexandria and Suez and the great variations in the personal equation of the observer at Mokattam are serious matters.

The operations east of Aden all along to Australia were decidedly made under better conditions and with more complete equipments, and, unlike the others (which were only chiefly made for the purposes of the observations of the Transit of Venus), they were intended for the establishment of fundamental longitudes.

The portion from Aden to Madras depends on the elaborate and refined operations of the officers of the Great Trigonometrical Survey of India, of which the interval Aden-Bombay, with its two independent and extremely accordant values, obtained under such uneven share of advantages, offers a remarkable instance of how a good result is sometimes found where we might be justified by the nature of the case in giving it but little weight.

From Bombay to Madras the telegraphic results, though in every respect highly trustworthy, are not corroborated by any other entirely independent telegraphic determination. It appears also that the geodetic value of this interval, derived from the principal triangulation, is $12''\cdot29 = 0\cdot819^{sec.}$ in excess of the telegraphic value, the difference being partly attributed to local attractions—(11) Preface, page xviii.

Up to this point we have another test for the whole of the operations in the longitude chain via Berlin-Ispahan-Kurrachee, and but for the doubts attached to the Kurrachee station this test would be invaluable.

We have now the determinations Madras-Singapore of 1871 and 1882. It is not unfair to assume the superiority of the latter value. The chief weakness of the earlier one arises, perhaps, in the carriage of the chronometers to considerable distances for the exchange of signals, and in the unknown personal equation of the observers. There is a difference of more than half a second of time between the two results, and it is not quite certain, though most probable, that the whole of this error is attributable to the observations of Dr. Oudemans and Mr. Pogson. The interval Singapore to Port Darwin depends solely on one set of operations—viz., those of 1883. I can only say that the observers felt satisfied about the quality of their work; but still the receiving of galvanic signals by observing the sudden motion of a beam of light not always regular or well defined, involves greater uncertainty than transit observations, and may be subject to comparatively large variations in its amount. The result is

partly checked by the two separate intervals formed by the intervention of Banjoewangie, but is not corroborated by entirely independent operations. The difference between the direct and indirect result is $0 \cdot 12^{sec.}$

There remain now the Australian operations. In the two intervals Port Darwin to Adelaide and Port Darwin to Melbourne, the unknown error of the results rests almost entirely on the time determinations at Port Darwin, as the exchange of signals was entirely automatic, and transit observations at the fixed observatories involve very little uncertainty.

The various measurements of the interval Sydney-Melbourne, as we have repeatedly observed in these pages, range from $24^{m.}\ 55 \cdot 10^{sec.}$ to $24^{m.}\ 55 \cdot 81^{sec.}$, which may give reason to suspect some unknown disturbing cause interfering with this kind of work. Fortunately, fresh determinations may be frequently repeated without inconvenience, and I believe it is the intention of the government astronomers of these colonies to make arrangements for that purpose.

We have, finally, the boundary longitudes.

Here an error of more than half a second of time was disposed of in what was thought the only possible way under the circumstances; but it does not by any means clear the doubts attached to the discrepancies produced by the operations of 1868.

These are the principal facts upon which an opinion is to be formed as to the amount of uncertainty inherent to the adopted results.

I think that the longitudes of the Australian observatories may be accepted as true only within one second of time.

Possible Improvements of the Adopted Values.

No doubt, even with the present means of astronomical science, the Australian longitudes could be strengthened by a new determination of the longitude of Aden, as recommended by Dr. Gill, and of the interval Ispahan-Kurrachee. The importance of these operations could not be overrated, and it is to be hoped that they will be undertaken at the first opportunity.

Appendix—Table I.

Reference Letter.	Difference of Longitude.	Computed Mean Error.	Description of Interval for which the Difference of Longitude is given.
	h. m. sec.	sec.	
(a)	2 05 06·240	0·098	Greenwich–Mokattam (Cairo).
(b)	0 05 32·550	0·122	Alexandria (Hunter's station) to Mokattam.
(c)	0 53 34·865	....	Greenwich–Berlin (Transit Circle).
(d)	0 04 28·316	0·058	Berlin–Malta.
(e)	1 01 30·646	0·030	Malta–Alexandria.
(f)	1 05 58·750	0·078	Berlin–Alexandria. Dr. Copeland's value.
(f_1)	1 05 59·020	0·078	Berlin–Alexandria. Dr. Auwers' value.
(g)	0 10 38·923	0·082	Alexandria (Hunter's station) to Suez (Löw's station). Dr. Copeland's value.
(g_1)	0 10 39·078	0·082	Alexandria (Hunter's station) to Suez (Löw's station). Dr. Auwers' value.
(h)	0 05 06·931	0·103	Mokattam–Suez (Hunter's station).
(i)	0 00 00·320	... ...	Suez (Hunter's station, east of Löw's station) to Dr. Gill's determination.
(i_1)	0 00 00·025	. . . . .	Suez (Hunter's station, east of Löw's station) to Captain Campbell's traverse mesaurement.
(k)	0 49 43·750	0·120	Suez (Löw's station) to Aden (Gill's station). Dr. Copeland's value.
(k_1)	0 49 43·733	0·120	Suez (Löw's station) to Aden (Gill's station). Dr. Auwers' value.
(k_{11})	0 49 42·662	0·060	Suez (Hunter's station) to Aden (Heaviside's station).
(l)	0 00 00·877	0·	Aden (Gill's station, east of Heaviside's station).
(m)	1 51 18·940	0·	Aden (Gill's station) to Bombay (Chamber's station, Colaba Observatory).
(m_1)	1 51 19·973	0·056	Aden (Heaviside's station) to Bombay (Heaviside's station).
(n)	0 00 00·134	.. ..	Bombay to Captain Heaviside's station (east of the Colaba Observatory Transit Instrument or Chamber's station).
(o)	0 29 43·530	0·058	Bombay (Heaviside's station) to Madras (Observatory Transit Circle).
(p)	2 33 05·440		Berlin–Ispahan.
(q)	1 01 13·090		Ispahan-Kurrachee (Addison's station).
(r)	0 53 06·220		Kurrachee–Madras (Addison and Pogson). General Addison's value.
(r_1)	0 53 05·850		Kurrachee–Madras (Addison and Pogson). Mr. Pogson's value.
(r_{11})	0 52 55·720		Kurrachee (Captain Campbell's station) to Madras Observatory. Determination by the officers of the G.T.S.
(s)	0 00 00·710		Kurrachee (Campbell's longitude station, west of Addison's station).
(t)	1 34 23·365		Madras (Observatory) to Singapore (flag staff on Fort Canning, 1871). Prof. Oudemans' value.
(t_1)	1 34 23·560		Madras (Observatory) to Singapore (flag staff on Fort Canning, 1871). Mr. Pogson's value.
(t_{11})	1 34 24·070	0·040	Madras (Observatory) to Singapore (Lieut. Norris' station).
(u)	1 47 57.480	0·046	Singapore (Lieut. Norris' and Captain Darwin's station) to Port Darwin (Baracchi's station).
(v)	0 00 01·510	....	(Lieut. Norris' station is the same as Captain Darwin's station). (Darwin's station, east of flag staff on Fort Canning, 1871).
(w)	0 42 06·780	0·076	Singapore (Darwin's station) to Banjoewangie (Capt. Helb's).
(w_1)	1 05 50·840	0·091	Banjoewangie (Helb's station) to Port Darwin (Baracchi's station).
(x)	0 30 57·800	0·041	Port Darwin (Baracchi's station) to Adelaide (Observatory).
(y)	0 25 33·840	0·050	Melbourne (Observatory) to Adelaide (Observatory).
(x_1)	0 56 31·660	0·044	Port Darwin (Baracchi's station) to Melbourne (Observatory).
(z)	0 24 55·400	0·091	Sydney (Observatory) to Melbourne (Observatory).

II.—List of Works Consulted.

(1) Report on the Determination of Differences of Longitude in the West Indies and Central America. By Lieut.-Commander F. M. Green, U.S.N.

(2) Smithsonian Contributions to Knowledge, No. 223, vol. 16.

(3) Astronomische Nachrichten, No. 2636.

(4) United States Coast Survey Report. App. 18.

(5) Royal Astronomical Society, vol. 51.

(6) Report on the Telegraphic Determination of Australian Longitudes, via Singapore, Banjoewangie, and Port Darwin.

(7) Annals of the Cape Observatory, vol. i., Part II. (Dr. Gill.)

(8) Account of Observations of the Transit of Venus of 1874. (Edited by Sir George Airy.)

(9) Dunecht Observatory Publications, vol iii. (By the Earl of Crawford and Balcarres.)

(10) Royal Astronomical Society, vol. 38. (General T. Addison, C.B.)

(11) Account of the Operations of the Great Trigonometrical Survey of India, vol. ix. (General J. T. Walker, C.B., R.E., F.R.S., &c.)

(12) Report of the Great Trigonometrical Survey of India for 1876-77.

(13) Telegraphic Determinations of the Difference of Longitude between Karachi, &c., and the Government Observatory, Madras. (By Norman Pogson, C.I.E., F.R.A.S., &c., Government Astronomer.)

(14) Astronomische Nachrichten, No. 2486. (Prof. J. A. C. Oudemans.)

(15) Telegraphic Determination of Longitudes in Japan, China, &c. (By Lieut. Commanders F. M. Green and C. H. Davis and Lieut. J. A. Norris, U.S.N.)

(16) Royal Astronomical Society, vol. xlviii. (By John Tebbutt, F.R.A.S., &c.)

(17) Report on the Determination of the Boundary Line of Colonies of South Australia and New South Wales. (By Charles Todd, F.R.A.S., Observer and Superintendent of Telegraphs, South Australia, 14th December, 1868.)

Since Mr. Baracchi compiled the preceding, a fresh determination, Greenwich-Madras via Potsdam, has been made (1894-96) by Capt. Burrard and Capt. Conyngham, and still later (1903) a re-determination of Greenwich-Potsdam, whereby the preceding suffers a small correction so as to bring Capt. Burrard's value for Potsdam in accord with that of Professor Albrecht. From the recently published details of Professors Albrecht and Wanach's work, it would appear that we now have a practically absolute value for the difference of longitude Greenwich-Potsdam, and hence Berlin, that will not suffer material correction.

The meridian of Madras is the one of reference for the Great Trigonometrical Survey of India, and on its position the one of Singapore rests.

For over a century observations have been taken, from time to time to determine the longitude of Madras. In 1891 the survey of India had not adopted the then best value, so that at the International Geographic Congress held at Berne in that year the question arose, why the known error in longitude of 2′ 30″ was not corrected on the Indian maps and charts. This gave rise to a discussion in India and the whole longitude work was reviewed, with the result that a determination *de novo* was decided upon, carrying the work directly from Greenwich via Potsdam, Teheran, Bushire and Karachi, where connection was made with the three arcs of the Great Trigonometrical Survey between Karachi and Madras. This is the work referred to above and carried out in 1894-96.

In Volume xvii., Appendix No. 2—Great Trigonometrical Survey of India, 1901, Major S. G. Burrard, R.E., tabulates the various independent values of Madras into Series A, B, C, D and E.

Series A leads via Pulkowa to Vladivostock, with thirteen links, carried out by the Russian general staff, and thence by officers of the U. S. navy via Shanghai, Hong Kong, St. James, Singapore to Madras.

Series B was obtained in connection with the German Transit of Venus expeditions of 1874 and 1882, but owing to some serious error at Karachi, its value is rejected.

Series C gives the results of the most recent (1894-96) determination and the details are given in Capt. Burrard's report. The value for Madras of this series, corrected for Dr. Albrecht's value of Potsdam will be used for deducing Singapore. The difference between this new value for Singapore and the one adopted in the Singapore-

Port Darwin determination will be applied to the present value of Sydney, Brisbane, and Wellington for comparison with the Canadian longitudes brought across the Pacific.

Series D.—This leads via Berlin, Malta, Alexandria, Suez, Aden, Bombay and Bellary to Madras.

Mr. (now Sir) David Gill, who was one of the observers on this series, writes in volume I. of the Annals of the Cape Observatory: 'In the case of Lord Lindsay's Expedition (i.e. of Series D.) the observations lay no claim to high refinement. They were made throughout in the open air, with small portable instruments, which in the case of Alexandria were placed on the roof of a hotel, where the observer had to abstain from movement during each complete observation, otherwise the level was disturbed by the change of his position. At Aden and Alexandria the chronometers had to be carried a long distance between the observing station and the telegraph office. The observers were without personal assistance and the crucial observations for time had often to be made under conditions of extreme fatigue, amounting on one or two occasions nearly to exhaustion on the part of the observer engaged. In fact the character of the work was only such as it was possible to organize and execute en route, and the results fully realised the accuracy expected from them.'

Series E. This leads from Greenwich to Mokattam (Cairo) and thence to Suez and Madras as in Series D.

This series, too, Sir David Gill considers wanting in that refinement essential for fundamental longitudes.

The result of the five series of operations, Capt. Burrard tabulates as follows:—

	Longitude of Madras.			Probable Error.
	h.	m.	sec.	sec.
Series A.	5	20	59·750	±·155
B.			59·010	±·163
C.			59·137	±·022
D.			59·233	±·127
E.			59·421	±·123

On the first link Greenwich-Potsdam of Series C, there is a check by another determination.

The adopted value of Berlin, as given in the Berliner Jahrbuch, up to 1903 is $0^{h.}\ 53^{m.}\ 34{\cdot}910^{sec.}$

Berlin-Potsdam, $1^{m.}\ 18{\cdot}721^{sec.}$, Astron. Geod. Arbeiten in 1891. Longitude Potsdam, $0^{h.}\ 52^{m.}\ 16{\cdot}189^{sec.}$ By Series C, $0^{h.}\ 52^{m.}\ 15{\cdot}953^{sec.}$, Vol. xvii. p. 208 G. T. S. India. Or $\cdot 234^{sec.}$ less than the German value.

The value of Potsdam of Series C, $0^{h.}\ 52^{m.}\ 15{\cdot}953^{sec.}$ is the mean of the two values $0^{h.}\ 52^{m.}\ 15{\cdot}623^{sec.}$ and $0^{h.}\ 52^{m.}\ 16{\cdot}283^{sec.}$, obtained by exchange of stations by the observers Capt. Burrard and Capt. Conyngham. This gives a difference of $\cdot 660^{sec.}$ between the two results, and the personal equation is half, or $\cdot 330^{sec.}$, a quantity larger than had been obtained by direct observation therefor both at Greenwich and in India.

In 1903 a re-determination of Greenwich-Potsdam was carried out by Dr. Albrecht and Mr. Wanach. Stations were exchanged and the observations made with a Repsold registering micrometer. The whole work was carried out with so high a degree of refinement, that it is not probable that the work will ever require revision or repetition.

From the above 1903 determination, we have Potsdam $0^{h.}\ 52^{m.}\ 16{\cdot}051^{sec.} \pm \cdot 003^{sec.}$ p.e.* or $\cdot 098^{sec.}$ more than that of series C, and $\cdot 138^{sec.}$ less than the former German value.

New Zealand.

In volume 35 of the Transactions of the New Zealand Institute, Mr. T. King, observer at Wellington, gives a full account of the various determinations made for

* P. 77. No. 15 Veröffentlichung des K. Preussischen Geodätischen Instituts.

the longitude of a prime meridian for New Zealand. This meridian, passing through the former Mount Cook observatory, is the one to which the surveys of New Zealand are referred. It may be remarked that the observatory was not on or near the well-known Mount Cook of the South or Middle island, but in Wellington on a site now occupied by prison buildings.

The longitude hitherto adopted for that meridian is $11^{h.}\ 39^{m.}\ 09{\cdot}92^{sec.}$, derived from moon culminations, 1869-71. In 1876 a telegraphic difference of longitude was obtained between Sydney and Wellington by Messrs. Russell and Stock. However, as the accurate longitude of Sydney was at that time in doubt, no definitive meridian for New Zealand resulted from the 1876 work.

In 1883, as already noted, Sydney was connected with Greenwich by a chain of telegraphically connected stations entering Australia at Port Darwin, and the resulting longitude was $10^{h.}\ 04^{m.}\ 49{\cdot}54^{sec.}$†

In the same year Messrs. Russell and Adams connected Sydney with Wellington (Mount Cook station), obtaining a difference of longitude $1^{h.}\ 34^{m.}\ 16{\cdot}983^{sec.} \pm {\cdot}020^{sec.}$ (A very full and interesting account of this good work is given by Mr. C. W. Adams in the report on the surveys of New Zealand for the years 1883-84.)

This gave for the longitude of Mount Cook Initial Station, $11^{h.}\ 39^{m.}\ 06{\cdot}52^{sec.}$

This value is less than the hitherto accepted value by $3{\cdot}40^{sec.}$, or 51 seconds of arc.

By triangulation a connection has been made between the Mount Cook station and the present observatory, both in Wellington. The latter was found east of the former $1{\cdot}21^{sec.}$, so that the longitude of the present Wellington Observatory, is $11^{h.}\ 39^{m.}\ 05{\cdot}31^{sec.}$ east of Greenwich.

This value is based on:—

1883, Wellington-Sydney. Adams and Russell.
1883-84, Sydney-Melbourne-Port Darwin. Ellery, Todd, Russell, Baracchi.
1883, Port Darwin-Singapore. Baracchi, Capt. Darwin.

As Singapore is dependent upon Madras, whose longitude has already been discussed, all New Zealand longitudes, by accepting the last quoted longitude for Wellington, will be affected by any change in the value of Madras. Although the 1883 value for Mount Cook initial station was at the time considered definitive, yet its value has not for a period of twenty years thereafter, been introduced on the Admiralty Charts (except on No. 1423) nor on the maps of New Zealand. This was due to the great labour involved in changing the engraved plates.

Mr. T. King in his report,* writes: 'I understand, however, that the Surveyor General purposes taking advantage of an intended reissue of the Department maps to revise the longitudes on the basis of Mr. Russell's and Mr. Adams' determination.'

The change of longitude by the $3{\cdot}40^{sec.}$, will shift the topography relative to the meridians about three quarters of a mile to the west.

LATITUDE.

For the differential longitude determinations, the value for the latitude enters only for computation of the star factors, and was not required to be of such accuracy as in geodetic computations.

Vancouver.—The value used was that of former years, this station having been occupied at various times for longitudes in British Columbia:—

$$\phi = 49^\circ\ 17'\ 48''$$

Fanning Island.—Mr. Werry observed here 29 pairs of stars between the 19th April and 11th May, 1903, Talcott's method, and obtained the value:—

$$\phi = +3^\circ\ 54'\ 37''{\cdot}53 \pm ''{\cdot}015$$

† Report on the Telegraphic Determination of Australian Longitudes.—Melbourne, 1886.
* Trans. New Zealand Institute Vol. 35, p. 446.

Suva, Fiji.—Between June 27 and July 27, 1903, Dr. Klotz obtained here 28 pairs of stars from which the latitude was found to be:—

$$\phi = -18° \ 08' \ 45''{\cdot}02 \pm ''{\cdot}014.$$

Norfolk Island.—Mr. Werry observed here 28 pairs of stars between Sept. 17 and 23, 1903, and obtained the value:—

$$\phi = -29° \ 00' \ 28''{\cdot}91 \pm '' {\cdot}014.$$

Southport, Queensland.—The transit instrument not being available for latitude work on account of the broken micrometer thread, several observations for latitude were taken by the method of observing pairs of stars at eastern and western elongation respectively, with a 6-inch transit theodolite, kindly loaned by Mr. A. A. Spowers, Chief Surveyor, Brisbane.

The mean value of three pairs was:—

$$\phi = -27° \ 58' \ 53''.$$

Brisbane.—The position of the observatory, where the observations were taken is (given in the Nautical Almanac):—

$$\phi = -27° \ 28' \ 00''{\cdot}0.$$

Sydney.—The position of the observatory, where the observations were taken is (given in the Nautical Almanac):—

$$\phi = -33° \ 51' \ 41''{\cdot}1.$$

Wellington.—The position of the observatory, where the observations were taken is:—

$$\phi = -41° \ 16' \ 47''{\cdot}1.$$

Doubtless Bay.—The observatory here was connected, through the courtesy of the Surveyor General, J. W. A. Marchant, by Mr. Vincent J. Blake, Government Surveyor, with Station 20 of the triangulation system, spread over the North Island.

The latitude of Station 20, based on initial Station Mt. Cook at Wellington, was furnished by the Surveyor General under date November 11, 1902, as—

$$\phi = -34° \quad 58' \quad 58''{\cdot}1$$

Applying it to Mr. Blake's survey we have:—

Station 20—A.	− 22″·87
Station A.	− 34° 59′ 20″·97
Station A—Observatory.	− 1″·07
Observatory.	− 34° 59′ 22″·04

The following is an abstract of the transit observations at the various stations:—

TRANSIT OBSERVATIONS.

Station: VANCOUVER. Date, April 10th, 1903. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer Correction.	v.
		h. m. s.	s.	s.	s.	s. r = + ·06	s.		h. m. s.	s.	s.
E	137	9 24 17·77	− ·80	+ ·35	− ·23	·04	− ·10	17·41	9 23 22·31	−55·10	·00
	419	29 14·01	− ·17	− ·03	+ ·04	·03	− ·02	13·80	28 18·79	·01	·09
	142	41 17·88	− ·13	− ·04	+ ·04	·02	− ·02	17·71	40 22·59	·12	+ ·02
	572	47 17·76	− ·08	− ·08	+ ·03	·01	− ·01	17·61	46 22·58	·03	·07
	423	56 02·42	− ·10	− ·06	+ ·03	·00	− ·02	02·27	55 07·11	·16	+ ·06
	145	10 02 59·87	− ·12	− ·05	+ ·03	·00	− ·02	59·71	10 02 04·56	·15	+ ·05
W	148	10 12 15·05	− ·24	− ·04	− ·04	+ ·01	− ·02	14·72	11 19·68	·04	·06
	149	17 30·65	− ·32	− ·02	− ·04	+ ·02	− ·02	30·27	16 35·16	·11	+ ·01
	426	23 14·10	− ·30	− ·02	− ·04	+ ·02	− ·02	13·74	22 18·56	·18	+ ·08
	150	27 51·35	− ·91	+ ·18	− ·14	+ ·03	− ·06	50·45	26 55·36	·09	·01
	431	41 25·80	− ·27	− ·03	− ·04	+ ·04	·02	25·48	40 30·37	·11	·01
	432	45 06·99	− ·20	− ·06	− ·03	+ ·04	− ·02	06·63	44 11·55	·08	·02

$a = -{}^{s}{\cdot}094 \qquad c = +{}^{s}{\cdot}033$

Chronometer correction at $10^{h}\ 00^{m} = -55^{s}{\cdot}098 \pm {}^{s}\,012$

TRANSIT OBSERVATIONS.

Station: VANCOUVER. Date, April 15th, 1903. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of cor. transit.	R. A.	Chronometer Correction.	v.
		h. m. s.	s.	s.	s.	s. r = + ·06	s.		h. m. s.	s.	s.
E	127	8 41 38·51	+ ·03	+ ·04	+ ·03	- ·05	- ·02	38·54	8 40 51·22	- 47·32	- ·13
	129	51 04·82	+ ·02	+ ·08	+ ·03	- ·04	- ·01	04·90	50 17 45	·45	·00
	132	55 09·67	+ ·04	+ ·02	+ ·04	- ·04	- ·02	09·71	54 22·34	·37	- ·08
	133	57 49·33	+ ·04	·00	- ·04	04	- ·02	49·35	57 02 01	·34	- ·11
	134	9 10 08·04	+ ·02	+ ·08	+ ·03	·03	- ·01	08·13	9 09 20·62	·51	- ·06
	136	15 57·97	+ ·03	+ ·03	+ ·04	- ·02	- ·02	58·03	15 10·49	·54	- ·09
	137	24 09·32	+ ·15	- ·41	+ ·21	- ·01	- ·10	09·16	23 21·68	·48	- ·03
W	142	41 10·07	- ·08	+ ·05	- ·03	- ·01	- ·02	10·00	40 22·50	·50	- ·05
	423	55 54·47	- ·06	- ·07	- ·03	+ ·02	- ·02	54·45	55 07·05	·40	- ·05
	145	10 02 52·00	- ·07	+ ·06	- ·03	+ ·03	- ·02	51·97	10 02 04·50	·47	- ·02
	148	12 07·15	- ·08	+ ·05	- ·03	+ ·04	- ·02	07·11	11 19·62	·49	- ·04
	149	17 22·68	- ·11	- ·02	- ·04	- ·04	- ·02	22·57	16 35·07	·50	- ·05
	426	23 06·11	- ·10	+ ·03	- ·04	+ ·05	- ·02	06·03	22 18·48	·55	- ·10
	150	27 43·10	- ·31	- ·21	·13	+ ·05	- ·06	42·44	26 55·04	·40	- ·05

$a = +^{s}\cdot111$ $c = +^{s}\cdot030$

Chronometer correction at 9^{h} $34^{m} = -47^{s}\cdot453 \pm {}^{s}\cdot014$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of cor. transit.	R. A.	Chronometer Correction.	v.
W	433	10 53 04·18	·35	·28	+ ·02	·03	- ·07	03·47	10 52 16·18	- 47·29	·02
	154	58 34·84	·17	·06	+ ·01	- ·02	- ·04	34·56	57 47·14	42	+ ·11
	434	11 00 50·18	·06	- ·08	+ ·01	- ·02	- ·02	50·17	11 00 02·82	·35	+ ·04
	155	05 02·11	·11	- ·01	- ·01	- ·02	- ·02	01·98	04 14·82	·16	- ·15
	156	09 46·42	- ·08	+ ·06	- ·01	- ·01	- ·02	46·38	08 59·04	·34	- ·03
E	160	11 16 57·38	+ ·05	+ ·08	·01	- ·01	- ·01	57·48	16 10·16	·32	+ ·01
	162	26 29·25	+ ·17	·12	- ·01	·00	- ·05	29·24	25 41·90	·34	- ·03
	163	41 45·14	+ ·09	·00	- ·01	+ ·02	- ·02	45·22	40 58 00	·22	- ·09
	164	44 56·01	- ·05	+ ·07	- ·01	+ ·02	- ·02	56·12	44 08·82	·30	- ·01
	166	49 33 40	+ ·10	- ·02	- ·01	+ ·03	- ·03	33·47	48 46.15	·32	+ ·01
	167	12 01 05 43	+ ·05	- ·08	- ·01	+ ·04	- ·02	05·57	12 00 18·24	·33	+ ·02

$a = -{}^{s}\cdot118$ $c = -{}^{s}\cdot005$

Chronometer correction at 11^{h} $23^{m} = -47^{s}\cdot309 \pm {}^{s}\cdot016$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of cor. transit.	R. A.	Chronometer Correction.	v.
						r = + 056					
E	177	13 08 10·13	- ·04	+ ·01	- ·01	- ·04	- ·02	10·13	13 07 22·99	- 47·14	- ·04
	178	20 50·75	+ ·06	- ·01	- ·01	- ·03	- ·03	50·75	20 03·61	·14	- ·04
	452	24 29·88	+ ·11	- ·09	- ·02	- ·02	- ·05	29·85	23 42·68	·17	- ·01
	179	30 34·50	+ ·02	+ ·02	- ·01	- ·02	- ·01	34·52	29 47·32	·20	+ ·02
	180	43 28·47	+ ·03	+ ·02	- ·01	·00	- ·02	28·51	42 41·34	·17	- ·01
	182	50 53·23	+ ·03	+ ·02	- ·01	·00	- ·02	53·27	50 06·14	·13	- ·05
W	184	14 02 35·68	- ·15	·02	- ·01	+ ·01	- ·03	35·48	14 01 48·27	·21	+ ·03
	458	06 47·86	- ·07	+ ·01	- ·01	+ ·02	- ·02	47·79	06 00·68	·11	- ·07
	459	10 04·29	- ·29	- ·07	- ·03	+ ·02	- ·07	03·85	09 16·72	·13	- ·05
	188	13 31·22	- ·10	·00	- ·01	+ ·02	- ·02	31·11	12 43·96	·15	- ·03
	190	22 43·31	- ·11	·00	- ·01	+ ·03	- ·02	43·20	21 55·88	·32	+ ·14
	192	28 28·41	- ·07	+ ·01	- ·01	+ ·04	- ·02	28·36	27 41·10	·26	+ ·08

$a = +^{s}\cdot029$ $c = +^{s}\cdot007$

Chronometer correction at 13^{h} $48^{m} = -47^{s}\cdot181 \pm {}^{s}\cdot013$

TRANSIT OBSERVATIONS.

Station: VANCOUVER. Date, April 16th, 1903. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer Correction.	v.
		h. m. s.	s.	s.	s.	s. r = + ·07	s.		h. m. s.	s.	s.
E	150.	10 27 41·11	·15	− ·26	+ ·12	− ·05	·06	40·71	10 26 54·98	45·73	+ ·02
	431.	41 16·02	·05	+ ·05	+ ·03	·03	·02	16·00	40 30·30	·70	− ·01
	432.	44 57·12	− ·03	+ ·09	+ ·03	− ·03	·02	57·16	44 11·49	·67	·04
	152.	48 40·90	·05	+ ·04	+ ·03	− ·02	− ·02	40·88	47 55 29	·59	·12
	434.	11 00 48·61	·04	+ ·09	+ ·03	− ·01	− ·02	48·66	11 00 02·82	·84	+ ·13
	155.	05 00 53	− 06	+ ·02	+ ·04	00	− ·02	00·51	04 14·80	·71	·00
W	159.	14 02·39	− ·21	+ ·04	− ·03	+ ·01	− ·02	02 18	13 16·48	·70	− ·01
	160.	16 55·82	− ·14	+ ·09	·03	+ ·01	01	55·74	16 10·15	·59	·12
	162.	26 28·22	·39	− ·14	·08	+ ·02	− 05	27·58	25 41·87	·71	·00
	438.	32 46·85	− ·12	+ ·10	− ·03	+ ·03	− ·01	46·82	32 01·06	·76	+ ·05
	164	44 54·65	·13	+ ·08	− ·03	+ ·04	·02	54·59	44 08·81	·78	+ ·07

$a = +^s\cdot 138$ $c = +^s\cdot 028$

Chronometer correction at $11^h\ 8^m = -45^s\cdot 708 \pm {}^s\cdot 017$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer Correction.	v.
W	177.	13 08 08·47	− ·01	+ ·06	+ ·06	− ·05	− ·02	08·51	13 07 23·00	− 45·51	− ·05
	451.	13 59 33	·01	+ ·03	+ ·07	− ·04	− ·02	59·36	13 13·84	·52	·04
	178.	20 49·13	− ·01	− ·03	+ ·09	− ·03	− ·03	49·12	20 03·61	·51	− ·05
	452.	24 28·44	·03	·20	+ ·17	·03	− ·05	28·30	23 42·67	·63	+ ·07
	454.	31 15·59	− ·01	+ ·04	+ ·06	− ·02	− ·02	15·64	30 30·11	·53	·03
	180.	43 26·84	·01	+ ·08	+ ·05	·01	− ·02	26·93	42 41·35	·58	+ ·02
E	182.	50 51·68	+ ·08	+ ·08	− ·05	·00	− ·02	51·77	50 06·15	·62	+ ·06
	183.	57 30·40	+ ·06	+ ·10	− ·05	+ 01	− ·01	30·51	56 44·88	·63	+ 07
	184.	14 02 33·67	+ ·20	·09	·12	+ ·02	− ·03	33·65	14 01 48·27	·38	− ·18
	458.	06 46·27	+ ·09	+ ·06	− ·06	+ ·02	− ·02	46·36	06 00·68	·68	+ ·12
	459.	10 02·58	+ ·37	− ·32	− 24	+ ·03	− ·07	02·35	09 16·73	·62	+ ·06
	188.	13 29·43	+ ·13	+ ·01	− ·07	+ ·03	·02	29·51	12 43·97	·54	− ·02
	192.	28 26·55	+ ·10	+ ·05	− ·06	+ ·05	− ·02	26·67	27 41·11	·56	·00

$a = +^s\cdot 139$ $c = -^s\cdot 050$

Chronometer correction at $13^h\ 48^m = -45^s\cdot 561 \pm {}^s\cdot 017$

TRANSIT OBSERVATIONS.

Station : VANCOUVER. Date, April 18th, 1903. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	r = + .03	s.		h. m. s.	s.	s.
E	141	9 36 43·36	− ·05	+ ·08	·02	− ·02	·02	43·43	9 36 00·10	−43·33	·07
	142	41 05·76	− ·06	+ ·06	·03	− ·02	·02	05·81	40 22·46	·35	− ·05
	144	47 59·92	+ ·06	+ ·05	− ·03	− ·02	− ·02	59·96	47 16·59	37	− ·03
	423	55 50·36	− ·05	+ ·08	− ·02	− ·01	·02	50·44	55 07·01	·43	− ·03
	162	11 26 25·30	− ·15	·13	− ·06	+ ·03	− ·05	25·24	11 25 41·81	·43	− ·03
	438	32 44·37	+ ·03	+ ·10	·02	+ ·03	− ·01	44·50	32 01·05	·45	+ ·05
W	152	10 48 38·72	·06	+ ·04	− ·03	+ ·01	·02	38·72	10 47 55·28	·44	+ ·04
	433	52 59·83	·25	·30	− ·08	+ ·01	·07	59·30	52 15·98	·32	− ·08
	153	56 45·30	·12	− ·05	− ·05	+ ·02	− ·04	45·15	56 01·67	·48	+ ·08
	434	11 00 46·12	·04	+ ·08	− ·02	+ ·02	·02	46·18	11 00 02·80	·38	− ·02
	155	04 58·16	·08	+ ·01	− ·03	+ ·02	·02	58·12	04 14·78	·34	·06
	156	09 42·39	·05	+ ·06	− ·02	+ ·02	·02	42·42	08 59·02	·40	·00
	159	13 59·90	·07	− ·04	− ·03	+ ·02	·02	59·90	13 16·46	·44	+ ·04

$a = +^s{\cdot}123$ $c = -^s{\cdot}024$

Chronometer correction at $10^h\ 24^m = -43^s{\cdot}402 \pm {}^s{\cdot}011$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
E	180	13 43 24·53	+ ·07	+ ·10	− ·04	·03	− ·02	24·61	13 42 41·36	43·25	− ·05
	182	50 49·31	− ·08	+ ·10	− ·04	− ·02	− ·02	49·41	50 06·16	·25	− ·05
	183	57 28·11	+ ·06	+ ·13	·04	·02	− ·01	28·23	56 44·90	·33	+ ·03
	184	14 02 31·60	+ ·19	− ·11	− ·09	− ·01	− ·03	31·55	14 01 48·29	·26	− ·04
	458	06 43·84	+ ·08	+ ·08	− ·04	− ·01	− ·02	43·93	06 00·70	·23	− ·07
	459	10 00·45	+ ·35	− ·43	− ·18	− ·01	− ·07	00·11	09 16·75	·36	+ ·06
	188	13 27·19	− ·12	+ ·01	− ·05	− ·01	− ·02	27·24	12 43·99	·25	− ·05
W	190	22 39·47	− ·11	− ·02	+ ·06	·00	− ·03	39·37	21 55·92	·45	+ ·15
	192	28 24·46	·07	+ ·07	+ ·04	·00	− ·02	24·48	27 41·13	·35	+ ·05
	197	42 06·22	− ·04	+ ·13	+ ·04	+ ·01	− ·01	06·35	41 22·97	·38	+ ·08
	198	51 45·59	− ·22	− ·28	+ ·14	+ ·01	− ·05	45·19	51 01·98	·21	− ·09
	199	59 02·92	− ·08	− ·04	+ ·05	+ ·02	− ·02	02·93	58 19·62	·31	+ ·01
	465	15 01 02·69	− ·07	− ·08	+ ·04	+ ·02	− ·02	02·74	15 00 19·46	·28	− ·02
	201	12 20·87	− ·08	− ·06	+ ·04	+ ·03	− ·02	20·90	11 37·61	·29	− ·01

$a = +^s{\cdot}186$ $c = -^s{\cdot}036$

Chronometer correction at $14^h\ 28^m = -43^s{\cdot}302 \pm {}^s{\cdot}010$

TRANSIT OBSERVATIONS.

Station : VANCOUVER. Date, April 21st, 1903. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·05	s.		h. m. s.	s.	s.
E	194	14 36 49·80	− ·01	+ ·09	− ·05	·03	− ·02	49·88	14 36 12·30	37·58	·10
	197	42 00·55	·00	+ ·12	− ·05	·02	− ·01	00·69	41 23·00	·69	− ·01
	198	51 39·84	+ ·06	− ·24	− ·17	·02	·05	39·76	51 02·03	·73	+ ·05
	199	58 57·14	+ ·04	+ ·03	− ·06	·01	− ·02	57·24	58 19·66	·58	− ·10
	465	15 00 57·06	+ ·03	+ ·07	− ·05	·00	·02	57·19	15 00 19·50	·69	− ·01
W	201	12 15·31	+ ·02	+ ·05	·06	·00	·02	15·30	11 37·65	·65	− ·03
	203	21 33·31	+ ·12	·20	·15	+ ·01	− ·04	33·05	20 55·43	·62	− ·06
	206	28 06·44	+ ·07	+ ·03	− ·06	− ·02	− ·02	06·48	27 28·79	·69	+ ·01
	209	31 14·60	+ ·06	+ ·07	− ·05	− ·02	·02	14·68	30 36·95	·73	+ ·05
	210	36 23·23	+ ·08	+ ·04	·06	+ ·02	·02	23·29	35 45·59	·70	+ ·02
	211	39 19·86	+ ·08	+ ·07	− ·05	·02	− ·02	19·96	38 42·26	·70	− ·02
	213	42 22·43	+ ·07	+ ·09	·05	− ·03	·02	22·55	41 44·78	·77	− ·09

$a = -^{s}\cdot159$ $c = -^{s}\cdot046$

Chronometer correction at $15^{h}\ 10^{m} = -37^{s}\cdot677 \pm {}^{s}\ 013$

TRANSIT OBSERVATIONS.

Station: VANCOUVER. Date, April 23rd, 1903. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = + ·69	s.		h. m. s.	s.	s.
W	154	10 58 21·94	·23	− ·08	+ ·06	− ·05	− ·04	21·60	10 57 46·92	−34·68	+ ·05
	155	11 04 49·48	− ·15	+ ·02	·04	·04	− ·02	49·33	11 04 14·70	·63	·00
	156	09 33·63	− ·10	·09	+ ·03	·03	− ·02	33·60	08 58·96	·64	+ ·01
	159	13 51·11	− ·13	+ ·06	+ ·03	·02	− ·02	51·03	13 16·40	·63	·00
	160	16 44·64	− ·08	12	+ ·03	·02	− ·02	44·67	16 10·09	·58	·05
E	162	26 16·65	− ·08	− ·18	− ·08	− ·01	− ·05	16·25	25 41·63	·62	− ·01
	438	32 35·63	− ·02	+ ·13	− ·03	·00	− ·01	35·70	32 01·01	·69	+ ·06
	163	41 32·52	− ·05	+ ·01	− ·04	+ ·02	− ·02	32·44	40 57·89	·55	− ·08
	164	44 43·32	− ·03	+ ·10	− ·03	·02	− ·02	43·36	44 08·77	·59	·04
	166	49 20·81	− ·05	− ·03	− ·04	·03	− ·02	20·70	48 46·03	·67	+ ·04
	167	12 00 52·81	− ·02	+ ·11	− ·03	+ ·05	− ·02	52·90	12 00 18·21	·69	− ·06

$a = -^s{\cdot}172 \qquad c = -^s{\cdot}025$

Chronometer correction at $11^h\ 29^m = -34^s{\cdot}633 \pm {}^s{\cdot}011$

E	177	13 07 57·49	− ·07	+ ·07	+ ·03	− ·06	− ·02	57·44	13 07 23·00	−34·44	− ·01
	178	20 38·20	− ·12	− ·03	− ·04	− ·03	− ·03	38·03	20 03·59	·44	− ·01
	452	24 17·54	− ·22	− ·24	+ ·08	− ·03	− ·05	17·08	23 42·61	·47	+ ·02
	454	31 04·62	− ·09	+ ·04	+ ·03	− ·02	− ·02	04·56	30 30·12	·44	− ·01
	180	43 15·84	− ·06	+ ·09	+ ·02	·00	− ·02	15·87	42 41·38	·49	+ ·04
W	182	50 40·71	− ·07	+ ·09	− ·02	+ ·01	− ·02	40·70	50 06·18	·52	+ ·05
	183	57 19·33	− ·05	+ ·13	− ·02	+ ·02	− ·01	19·40	56 44·93	·47	+ ·02
	184	14 02 23·03	− ·18	− ·11	− ·05	+ ·03	− ·03	22·69	14 01 48·30	·39	− ·06
	458	06 35·17	− ·08	+ ·08	− ·03	+ ·03	− ·02	35·15	05 60·73	·42	− ·03
	459	09 52·12	− ·34	− ·40	− ·11	+ ·04	− ·07	51·24	09 16·76	·48	+ ·03
	190	22 30·53	− ·13	− ·02	− ·04	+ ·06	− ·03	30·37	21 55·95	·42	− ·03

$a = -^s{\cdot}173 \qquad c = -^s{\cdot}023$

Chronometer correction at $13^h\ 45^m = -34^s{\cdot}451 \pm {}^s{\cdot}008$

TRANSIT OBSERVATIONS.

Station: VANCOUVER. Date, April 24th, 1903. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = + ·09	s.		h. m. s.	s.	s.
E	154.	10 58 18·70	+ ·92	- ·05	- ·02	·09	·04	19·42	10 57 46·89	-32·53	+ ·06
	156.	11 09 31·09	+ ·41	+ ·06	- ·01	- ·08	·02	31 45	11 08 58·95	·50	+ ·03
	159.	13 48 45	+ ·50	+ ·04	- ·01	·07	·02	48·89	13 16·39	·50	+ ·03
	161.	19 26·30	+ ·35	+ ·07	- ·01	·06	·02	26 63	18 54 06	·57	+ ·10
	166.	49 17·66	+ ·75	·02	- ·02	- ·02	·03	18·32	48 46·01	31	- ·16
W	170.	12 15 30·85	· ·22	+ 08	+ ·01	+ ·02	·02	31 16	12 14 58·79	37	- ·10
	442.	21 38·30	+ ·44	+ ·02	+ ·01	+ ·03	·02	38·78	21 06·38	·40	- ·07
	171.	29 55·07	+ ·94	·12	+ ·03	+ ·04	04	55·92	29 23·43	·49	+ 02
	172.	37 18·99	+ ·22	+ ·08	+ ·01	+ ·06	·01	19·35	36 46·95	·40	·07
	174.	51 17·49	- ·24	+ ·08	+ ·01	+ ·07	·01	17·88	50 45·28	60	+ ·13
	175.	52 03·59	- ·43	+ ·03	+ ·01	+ ·08	·02	04·12	51 31·62	·50	+ ·03
	451.	13 13 45·76	+ ·45	+ ·02	+ ·01	+ ·10	·02	46 32	13 13 13 84	·48	+ 01

$a = +^{s}\cdot 110 \qquad c = -^{s}\cdot 010$

Chronometer correction at $12^{h}\ 01^{m} = -32^{s}\cdot 471 \pm {}^{s}\cdot 020$

TRANSIT OBSERVATIONS.

Station: VANCOUVER. Date, April 25th, 1903. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = + ·09	s.		h. m. s.	s.	s.
E	184	14 02 19·94	− ·44	− ·08	− ·03	·05	− ·03	19·31	14 01 48·30	−31·01	+ ·07
	190	22 27·13	·32	− ·01	·02	·02	− ·03	26·73	21 55·96	30·77	·17
	192	28 12·37	·21	+ ·05	− ·01	·01	− ·02	12·17	27 41·18	30·99	+ ·05
	194	36 43·48	− ·17	+ ·07	− ·01	·00	− ·02	43·35	36 12·33	31·02	+ ·08
W	197	41 54·05	− ·18	+ ·09	+ ·01	+ ·01	− ·01	53·97	41 23·04	30·93	− ·01
	198	51 34·06	·88	− ·19	+ ·06	·02	− ·05	33·02	51 02·07	30·95	+ ·01
	199	58 50·97	− ·34	+ ·02	+ ·02	+ ·03	− ·02	50·68	58 19·70	30·98	+ ·04
	465	15 00 50·64	·27	+ ·04	+ ·01	+ ·03	− ·02	50·43	15 00 19·54	30·89	− ·05
	201	12 08·86	− ·30	+ ·05	+ ·01	+ ·05	− ·02	08·65	11 37·70	30·95	+ ·01

$a = +\cdot 124$ c [illegible] $\cdot 013$

Chronometer correction at $14^h\ 37^m = -30^s\cdot 943 \pm {}^s\cdot 020$

TRANSIT OBSERVATIONS.

Station : VANCOUVER. Date, April 26th, 1903. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = + ·10	s.		h. m. s.	s.	s.
E	150	10 27 24·44	− ·22	− ·34	+ ·03	− ·09	− ·06	23·76	10 26 54·29	−29·47	− ·11
	431	40 59·72	− ·07	+ ·06	+ ·01	− ·07	− ·02	59·63	40 30·16	·47	− ·11
	432	44 40·93	− ·05	+ ·11	+ ·01	− ·06	− ·02	40·92	44 11·38	·54	− ·04
	153	56 31·42	− ·11	− ·04	+ ·01	·04	− ·03	31·21	56 01·48	·73	+ ·15
	434	11 00 32·34	− ·05	+ ·12	+ ·01	03	− ·02	32·37	11 00 02·72	·65	+ ·07
	155	04 44·39	− ·08	+ ·02	+ ·01	− ·03	− ·02	44·29	04 14·64	·65	+ ·07
	156	09 28·62	− ·06	+ ·09	+ ·01	·02	− ·02	28·62	08 58·93	·69	+ ·11
W	438	32 30·49	− ·09	+ ·14	− ·01	− ·02	− ·01	30·54	32 00·99	·55	·03
	163	41 27·68	− ·21	+ ·01	− ·01	+ ·04	− 02	27·49	40 57·85	·64	+ ·06
	165	46 10·12	− ·10	+ ·13	− ·01	+ ·04	− ·02	10·16	45 40·65	·51	− ·07
	166	49 15·77	− ·24	− ·03	− ·01	+ 05	− ·03	15·51	48 45·98	·53	·05
	167	12 00 47·63	− ·11	+ ·12	− ·01	+ ·07	− ·02	47·68	12 00 18·19	·49	− ·09
	168	08 13·67	− ·60	− ·42	− ·04	+ ·08	− ·07	12·62	07 43·01	·61	+ ·03
	170	15 28·19	− ·09	+ ·14	− ·01	+ ·09	− 01	28·31	14 58·78	·53	·05

$a = +^s\cdot179 \qquad c = +^s\cdot008$

Chronometer correction at $11^h\ 20^m = -29^s\cdot576 \pm {}^s\cdot017$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	182	13 50 35·71	− ·19	+ ·03	+ ·04	− ·07	− ·02	35·50	13 50 06·20	−29·30	+ ·04
	183	57 14·34	− ·14	+ ·04	+ ·04	− ·06	− ·01	14·21	56 44·94	·27	+ ·01
	458	14 06 30·17	− ·20	+ ·02	+ ·04	− ·05	− ·02	29·96	14 05 60·74	22	− ·04
	459	09 46·88	− ·84	− ·11	+ ·18	− ·04	− ·07	46·00	09 16·74	·26	·00
	188	13 13·46	− ·29	·00	+ ·05	·04	− ·02	13·16	12 44·03	·13	·13
	190	22 25·43	− ·33	·00	+ 06	− ·02	− ·03	25·11	21 55·97	·14	− ·12
	192	28 10·62	− ·13	+ ·04	+ ·04	− ·01	− ·01	10·55	27 41·19	·36	+ ·10
E	197	41 52·32	− ·03	+ ·04	− 04	+ 01	− ·01	52·29	41 23·05	·24	− ·02
	198	51 31·79	− ·17	− ·07	− ·14	+ ·02	− ·05	31·38	51 02·08	·30	+ ·04
	199	58 49·02	− ·06	+ ·01	− ·05	+ ·04	− ·02	48·94	58 19·71	23	− ·03
	465	15 00 48·93	− ·05	+ ·02	− ·04	+ ·04	− ·02	48·88	15 00 19·55	·33	+ ·07
	201	12 07·05	− ·06	+ ·02	− ·04	+ ·06	− ·02	07·01	11 37·71	·30	+ ·04
	202	21 21·04	− ·06	+ ·01	− ·05	+ ·07	− ·02	20·99	20 51·70	·29	+ ·03

$a = +^s\cdot049 \qquad c = -^s\cdot037$

Chronometer correction at $14^h\ 35^m = -29^s\cdot260 \pm {}^s\cdot015$

TRANSIT OBSERVATIONS.

Station: FANNING ISLAND. Date, April 15th, 1903. Observer: F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = + ·11	s.		h. m. s.	m. s.	s.
E	149............	10 15 20·14	+ ·09	·29	− ·53	− ·06	− ·02	19·33	10 16 35·07	+1 15·74	+ ·13
	574............	20 10·45	+ ·09	+ ·13	− ·41	− ·05	− ·02	10·19	21 25·93	·74	+ ·13
	427............	23 12 72	+ ·10	− ·51	− ·71	·04	− ·02	11·54	24 27·50	·96	· ·09
	ρ Leonis........	26 28·63	+ ·09	− ·04	− ·40	− ·03	− ·02	28·23	27 41·18	·95	− ·08
	576............	35 14·47	+ ·09	+ ·03	− ·40	− ·02	− ·02	14·15	36 30·05	·90	− ·03
W	ι Antliæ........	50 57·83	− ·02	+ ·29	+ ·49	+ ·01	− ·02	58·58	52 14·54	·96	· ·09
	d Leonis... ...	54 18·96	− ·02	·00	+ ·40	+ ·02	− ·02	19·34	55 35·10	·76	+ ·11
	434.	58 46·73	− ·02	− ·02	+ ·40	+ ·02	− ·02	47·09	11 00 02·82	·73	+ ·14
	578....	11 05 38·98	− ·02	+ ·17	+ ·43	+ ·04	− ·02	39·58	06 55·48	·90	- ·03
	156...	07 42 83	− ·02	− ·11	+ ·42	+ ·04	− ·02	43·14	08 59·04	·90	− ·03
	579............	13 15·15	− ·02	+ ·11	+ ·41	+ ·05	− ·02	15·68	14 31·64	·96	·09

$a = +^{s}\cdot355$ $c = {}^{s}\cdot396$

Chronometer correction at $10^{h}\ 45^{m} = +1^{m}\ 15^{s}\cdot865 \pm {}^{s}\cdot021$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	τ Leonis.......	11 21 42·72	− ·03	·00	+ ·41	− ·07	− ·02	43·01	11 22 59·06	+1 16·05	− ·04
	581............	26 59·65	− ·03	+ ·33	+ ·48	− ·06	− ·02	60·35	28 16·38	16·03	− ·02
	438............	30 44·82	− ·03	+ ·03	+ ·41	− ·05	− ·02	45·16	32 01·07	15·91	+ ·10
	164.......... ..	42 52·49	− ·03	− ·10	+ ·43	− ·03	− ·02	52·74	44 08·82	16·08	− ·07
	B Centauri....	45 03·70	− ·03	+ ·52	+ ·58	− ·03	− ·03	04·71	46 20·76	16·05	- ·04
	π Virginis......	54 40 03	− ·03	− ·03	+ ·41	− ·01	− ·01	40·36	55 56·30	15·94	+ ·07
E	582............	12 03 55·05	− ·05	+ ·23	− ·44	+ ·01	− ·02	54·78	12 05 10·63	15·85	+ ·16
	170............	13 43·35	− ·05	+ ·03	− ·41	+ ·02	− ·02	42·92	14 58·82	15·90	+ ·11
	584............	23 37·44	− ·05	+ ·17	− ·43	+ ·04	− ·02	37·15	24 53 14	15·99	+ ·02
	585............	28 04 13	− ·05	+ ·24	·44	+ ·05	− ·02	03·91	29 20·04	16·13	− ·12
	172..	35 31·18	− ·05	+ ·04	− ·41	+ ·06	− ·02	30·80	36 46·96	16·16	− ·15
	31 Comæ.......	45 45·34	− ·05	+ ·23	− ·46	+ ·08	− ·02	44·66	47 00·65	15·99	+ ·02

$a = +^{s}\cdot495$ $c = -^{s}\cdot410$

Chronometer correction at $12^{h}\ 00^{m} = +1^{m}\ 16^{s}\cdot005 \pm {}^{s}\cdot023$

TRANSIT OBSERVATIONS.

Station : FANNING ISLAND. Date, April 16th, 1903. Observer: F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r=+·19	s.		h. m. s.	m. s.	s.
E	γ Cancri........	8 36 22·44	–·05	+·04	+·19	–·14	–·02	22·46	8 37 41·85	+1 19·39	+·07
	α Mali.........	38 23·60	–·05	·10	+·21	–·13	–·02	23·51	39 43·03	·52	06
	127.	39 31·65	–·06	+·07	+·20	–·13	–·02	31·71	40 51·19	·48	·02
	131............	51 53·09	–·07	+·02	+·18	·09	–·02	53·11	53 12·43	·32	+·14
	132............	53 02·62	–·07	+·12	+·24	–·09	–·03	02·79	54 22·32	·53	–·07
	133.	55 42·30	–·08	+·14	+·26	–·08	–·03	42·51	57 01·99	·48	·02
W	κ Cancri.. . . .	9 01 11·94	–·02	+·02	–·18	·06	–·02	11·68	9 02 31·18	50	–·04
	142.	39 03·13	–·02	+·05	–·19	+·06	–·02	03·01	40 22·49	·48	–·02
	143.	42 48·51	–·03	+·23	–·35	+·07	–·06	48·37	44 07·81	·44	+·02
	572............	45 03·23	–·02	–·02	–·18	+·08	–·02	03·07	46 22·49	·42	+·04
	μ Leonis... ...	45 57·31	–·02	–·06	–·20	+·08	–·02	57·21	47 16·62	·41	+·05
	423......	53 47·70	–·02	+·01	–·18	+·10	–·02	47·59	55 07·03	·44	+·02
	145.	10 00 45·00	–·02	+·03	–·19	+·14	–·02	44·94	10 02 04·49	·55	–·09

$a = -^{s}·142 \quad c = +^{s}·177$

Chronometer correction at $9^{h}\ 20^{m} = +1^{m}\ 19^{s}·456 \pm {}^{s}·014$

W	576......... ..	10 35 10·67	–·05	–·02	·25	–·08	–·02	10·25	10 36 30·05	+1 19·80	·03
	431.	39 10·76	–·05	+·14	–·29	·06	–·02	10·48	40 30·30	·82	–·05
	μ Argûs........	41 19·68	–·05	·31	·38	–·06	–·02	18·86	42 38·63	·77	·00
	577............	43 33·14	–·05	·09	–·26	–·05	–·03	32·66	44 52·42	·76	+·01
	ι Antliæ........	50 55·29	–·05	–·21	–·31	·03	–·02	54·67	52 14·54	·87	·10
	d Leonis........	54 15·84	–·05	·00	–·25	–·02	–.03	15·49	55 35·10	·61	+·16
E	155............	11 02 54·44	–·01	+·24	+·35	+·01	–·02	55·01	11 04 14·80	·79	–·02
	578.....	05 35·52	·00	–·13	+·27	+·02	–·03	35·65	06 55·47	·82	–·05
	156............	07 38·92	·00	+·09	+·26	+·02	–·02	39·27	08 59·07	·80	–·03
	579....	13 11·73	·00	–·09	+·25	+·04	–·02	11·91	14 31·63	·72	+·05
	160........... .	14 50·23	·00	+·01	+·25	+·04	–·02	50·51	16 10·15	·64	+·13
	τ Leonis........	21 38·87	·00	·00	+·25	+·06	–·02	39·16	22 59·06	·90	–·13
	438............	30 41·03	·00	–·02	+·25	+·09	–·02	41·33	32 01·06	·73	+·04

$a = -^{s}·261 \quad c = +^{s}·246$

Chronometer correction at $11^{h}\ 00^{m} = +1^{m}\ 19^{s}·770 \pm {}^{s}·017$

TRANSIT OBSERVATIONS.

Station : Fanning Island. Date, April 18th, 1903. Observer : F. W. O. Werry.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = + ·22	s.		h. m. s.	m. s.	s.
E	129	8 47 51·09	− ·03	− ·01	+ ·30	·27	− ·02	51·12	8 50 17·40	+2 26 28	− ·20
	133	54 35·90	− ·04	− ·29	+ ·43	− ·24	·03	35·81	57 01·94	·13	− ·05
	κ Cancri	9 00 05·05	− ·03	·03	+ ·30	− ·22	− ·02	05·11	9 02 31·15	·04	+ ·04
	134	06 54·40	− ·03	+ ·01	+ ·30	·20	·02	54·52	09 20·58	·06	+ ·02
	417	11 09·68	− ·03	− ·67	+ ·31	− ·18	− ·02	09·75	13 35·65	25·90	+ ·18
W	ρ Leonis	10 25 18·42	− ·01	·09	− ·30	− ·09	− ·02	18·11	10 27 44·14	26·03	+ ·05
	434	57 36·96	− ·01	− ·05	− ·30	− ·21	·02	36·81	11 00 02·80	25·99	+ ·09
	155	11 01 49·68	·00	·81	− ·42	− ·22	− ·03	48·64	04 14·77	26·13	− ·05
	578	04 29·01	− ·01	+ ·42	− ·32	− ·23	·02	29·31	06 55·46	·15	− ·07
	157	06 45·21	·02	·20	− ·31	− ·24	− ·02	44·90	09 11·00	·10	− ·02

$a_1 = + ^s ·280$ $a_2 = + ^s ·875$ $c = - ^s ·296$

Chronometer correction at $10^h\ 00^m = +2^m\ 26^s·081 \pm ^s·026$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	579	11 12 05·21	− ·02	+ ·26	− ·30	− ·14	− ·02	04·99	11 14 31·62	+2 26·63	− ·15
	160	13 44·17	− ·03	− ·03	− ·29	− ·13	− ·02	43·67	16 10·13	·46	+ ·02
	164	41 42·97	− ·03	·16	− ·30	− ·03	− ·02	42·43	44 08·81	·38	+ ·10
	166	46 21·27	− ·03	−1·07	− ·50	− ·01	− ·04	19·62	48 46·10	·48	·00
E	167	11 57 51·58	+ ·05	− ·07	+ ·29	+ ·03	− ·02	51·86	12 00 18·23	·37	+ ·11
	582	12 02 43·31	+ ·04	+ ·38	+ ·31	+ ·04	− ·02	44·06	05 10·62	·56	− ·08
	169	08 14·06	+ ·05	−1·23	+ ·54	+ ·07	− ·04	13·45	10 40·02	·57	− ·09
	170	12 31·77	− ·05	+ ·06	+ ·29	+ ·08	− ·02	32·23	14 58·81	·58	·10
	585	26 52·71	+ ·04	+ ·40	+ ·31	+ ·13	− ·02	53·57	29 20·03	·46	+ ·02
	ρ Virginis	34 34·02	+ ·05	− ·10	+ ·30	+ ·16	− ·02	34·41	37 00·73	·32	+ ·16

$a = + ^s ·819$ $c = + ^s ·290$

Chronometer correction at $11^h\ 50^m = +2^m\ 26^s·481 \pm ^s·025$

TRANSIT OBSERVATIONS.

Station: Fanning Island. Date, April 23rd, 1903. Observer: F. W. O. Werry.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	*v*.
		h. m. s.	s.	s.	s.	s. r = + ·17	s.		h. m. s.	s.	s.
E	λ Argûs...	9 03 40·30	+ ·06	+ ·52	+ ·37	− ·07	− ·03	41·15	9 04 27·23	+ 46·08	− ·08
	134...	08 34·04	− ·04	+ ·01	+ ·27	− ·06	− ·02	34·28	09 20·50	·22	− ·06
	417...	12 49·36	− ·04	− ·14	+ ·28	− ·04	− ·02	49·48	13 35·57	·09	+ ·07
	136...	14 24·25	+ ·04	− ·33	+ ·33	− ·04	− ·03	24·22	15 10·34	·12	+ ·04
	h Mali...	16 26·56	− ·03	+ ·28	+ ·30	− ·04	− ·02	27·11	17 13·34	·23	− ·07
W	ψ Argûs...	26 08·21	− ·02	+ ·48	− ·35	− ·01	− ·03	08·28	26 54·42	·14	+ ·02
	419...	27 33·17	− ·03	− ·36	− ·33	− ·01	− ·03	32·41	28 18·54	·13	+ ·03
	κ Hydræ...	34 54·94	− ·05	+ ·16	− ·28	+ ·01	− ·02	54·76	35 40·96	·20	− ·04
	572...	45 36·49	− ·06	+ ·07	− ·27	+ ·04	− ·02	36·25	46 22·39	·14	+ ·02
	422...	51 01·00	− ·07	− ·42	− ·36	+ ·06	− ·03	00·18	51 46·41	·23	− ·07
	423...	54 21·13	− ·09	− ·04	− ·27	+ ·08	− ·02	20·79	55 06·94	·15	+ ·01

$a = +^{s}{\cdot}523 \qquad c = +^{s}{\cdot}267$

Chronometer correction at $9^{h}\ 30^{m} = +46^{s}{\cdot}157 \pm {}^{s}{\cdot}012$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	*v*.
W	427...	10 23 42·45	− ·10	·92	·40	− ·08	− ·04	40·91	10 24 27·29	+46·38	·00
	ρ Leonis...	26 58·18	− ·07	− ·06	− ·22	− ·07	− ·02	57·74	27 44·08	34	+ ·04
	576...	35 43·92	− .07	+ ·06	− ·22	− ·04	− ·02	43·63	36 29·97	·34	+ ·04
	μ Argûs...	41 51·76	− ·07	+ ·77	− ·33	− ·02	− ·03	52·08	42 38·48	·40	·02
	d Leonis...	54 48·92	− ·07	− ·01	− ·22	+ ·01	− ·02	48·61	55 35·03	·42	− ·04
E	578...	11 06 08·52	− ·05	+ ·31	+ ·24	+ ·04	− ·02	09·04	11 06 55·41	·37	+ ·01
	157...	08 24·48	− ·06	− ·15	+ ·23	+ ·06	− ·02	24·54	09 10·97	·43	·05
	579...	13 44·79	− ·05	+ ·20	+ ·23	+ ·07	− ·02	45·22	14 31·58	·36	+ ·02
	160...	15 23·56	− ·06	− ·03	+ ·22	+ ·07	− ·02	23·74	16 10·09	·35	+ ·03
	τ Leonis...	22 12·33	− ·06	+ ·01	+ ·22	+ ·08	·02	12·56	22 59·00	·44	− ·06
	581...	27 29·22	− ·05	+ ·43	+ ·26	+ ·11	− ·02	29·95	28 16·31	·36	+ ·02

$a = +^{s}{\cdot}640 \qquad c = +^{s}{\cdot}220$

Chronometer correction at $10^{h}\ 50^{m} = +46^{s}{\cdot}382 \pm {}^{s}{\cdot}008$

TRANSIT OBSERVATIONS.

Station: FANNING ISLAND. Date, April 26th, 1903 Observer: F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = + ·16	s.		h. m. s.	s.	s.
E	h Mali........ ...	9 16 14·08	− ·10	+ ·25	+ ·20	− ·14	− ·02	14·27	9 17 13·28	+59·01	+ ·02
	140...............	25 25·34	− ·10	− ·56	+ ·29	·12	− ·03	24·82	26 23·92	59·10	− ·07
	419........ ..	27 19·78	− ·11	− ·31	+ ·23	− ·12	− ·03	19·44	28 18·49	59·05	− ·02
	142..	39 23·43	− ·12	− ·17	+ ·20	·08	− ·02	23·24	40 22·33	59·09	− ·06
	572.......	45 23·30	− ·10	+ ·06	+ ·18	− ·07	− ·02	23·35	46 22·35	59.00	+ ·03
	α Leonis........	46 17·71	− ·10	− ·20	+ ·20	− ·06	− ·02	17·53	47 16·46	58·93	+ ·10
W	423...............	54 08·16	− ·09	− ·04	− ·18	− ·04	− ·02	07·79	55 06·91	59·12	− ·09
	145...	10 01 05·81	− ·09	− ·11	− ·19	− ·03	− ·02	05·37	10 02 04·34	58·97	+ ·06
	573..	04 54·41	− ·09	+ ·13	− ·18	− ·02	− ·02	54·23	05 53·28	59·05	·02
	η Velorum.......	09 42·70	− ·09	+ ·44	− ·24	·00	− ·03	42·78	10 41·86	59·08	− ·05
	149.............	15 36·46	− ·09	− ·38	− ·24	+ ·01	− ·03	35·73	16 34·86	59·13	− ·10
	434...............	59 03·91	− ·03	− ·03	− ·18	+ ·13	− ·02	03·78	11 00 02·73	58·95	+ ·08
	155.	11 03 16·29	− ·03	− ·43	− ·25	+ ·14	− ·03	15·69	04 14·64	58·95	+ ·08

$a = +^{s}{\cdot}459 \qquad c = +^{s}{\cdot}180$

Chronometer correction at $10^{h}\ 10^{m} = +59^{s}{\cdot}034 \pm {}^{s}{\cdot}015$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	157.....	11 08 12·13	− ·02	·13	− ·24	− ·08	− ·02	11·64	11 09 10·94	+59·30	− ·02
	579..	13 32 42	·02	+ ·19	− ·24	− ·07	− ·02	32·26	14 31·55	·29	− ·01
	160..............	15 11 08	− ·02	− ·02	− ·23	− ·06	− ·02	10·73	16 10·06	·33	− ·05
	τ Leonis.......	22 00·06	− ·01	+ ·01	− ·23	− ·04	− ·02	59 77	22 58·97	·20	+ ·08
	581...............	27 16·87	− ·01	+ ·39	− ·27	− ·04	− ·02	16·92	28 16·28	·36	− ·08
	438........	31 01·96	·01	+ ·04	·23	− ·03	− ·02	01·71	32 00·99	·28	·00
E	163...............	39 58·79	+ ·02	− ·61	+ ·35	·00	− ·03	58·52	40 57·85	·33	− ·05
	B Centauri......	45 20·42	+ ·02	+ ·60	+ ·33	+ ·02	− ·03	21·36	46 20·56	·20	− ·08
	π Virginis.......	54 56 83	+ ·02	− ·03	+ ·23	− ·04	− ·02	57·07	55 56·26	·19	− ·09
	167..	59 18·71	+ ·01	·05	+ ·23	− ·05	− ·02	18·93	12 00 18·19	·26	− ·02
	169........	12 09 40 96	+ ·02	− ·87	+ ·43	+ ·08	− ·04	40·58	10 39·89	·31	− ·03
	170............ .	13 59·14	+ ·01	+ ·04	+ ·23	+ ·09	− ·02	59·49	14 58·78	·29	− ·01

$a = +^{s}{\cdot}579 \qquad c = +^{s}{\cdot}231$

Chronometer correction at $11^{h}\ 40^{m} = +59^{s}{\cdot}278 \pm {}^{s}{\cdot}012$

TRANSIT OBSERVATIONS.

Station: FANNING ISLAND. Date, June 2nd, 1903. Observer: F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = + ·10	s.		h. m. s.	s.	s.
E	179	13 30 01·77	−·05	+·03	+·10	−·08	−·02	01·75	13 29 47·28	−14·47	+·05
	m Virginis	36 47·98	−·05	+·10	+·10	−·07	−·02	48·04	36 33·68	·36	−·06
	180	42 55·97	−·05	−·12	+·10	·05	−·02	55·83	42 41·29	·54	+·12
	588	44 52·88	−·05	+·18	+·10	−·05	−·02	53·04	44 38·65	·39	−·03
	182	50 20·75	−·05	·13	+·10	−·04	−·02	20·61	50 06·12	·49	+·07
	457	57 03·43	−·05	−·22	+·11	·03	−·02	03·22	56 48·75	·47	+·05
W	192	14 27 56·08	−·14	−·25	−·11	+·02	−·02	55·58	14 27 41·19	·39	·03
	196	38 14·07	−·13	+·08	−·10	+·04	−·02	13·94	37 59·48	·46	+·04
	590	45 48·10	−·13	+·17	−·10	+·05	−·02	48·07	45 33·53	·54	+·12
	463	51 55·52	−·14	−·09	−·10	+·06	−·02	55·23	51 40·93	·30	·12
	199	58 34·74	−·14	·38	−·14	+·07	−·03	34·12	58 19·78	·34	−·08
	465	15 00 34·34	−·14	−·21	−·11	+·08	−·02	33·94	15 00 19·69	·25	·17

$a = -{}^{s}\cdot476 \qquad c = -{}^{s}\cdot096$

Chronometer correction at $14^h\ 15^m = -14^s\cdot419 \pm {}^s\cdot020$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	592	15 06 58·87	−·13	+·33	−·12	−·07	−·02	58·86	15 06 44·48	14·38	+·05
	466	10 39·26	−·13	−·02	·11	·06	−·02	38·92	10 24·63	·29	·04
	201	11 53·05	−·13	·48	−·13	−·06	−·02	52·23	11 37·88	·35	+·02
	γ Lupi	28 58·23	·13	+·74	−·14	·03	−·03	58·64	28 44·37	·27	·06
	593	30 23·27	−·13	+·25	·11	−·03	−·02	23·23	30 08·90	·33	·00
E	221	16 06 00·21	−·07	·75	+·15	+·03	−·03	59·54	16 05 45·29	·25	·08
	222	09 32·69	−·06	+·10	+·11	+·03	−·02	32·85	09 18·51	·34	−·01
	223	13 28·28	−·06	+·12	+·11	+·04	−·02	28·47	13 14·11	·36	+·03
	225	17 55·46	−·06	·22	+·12	+·05	−·02	55·33	17 41·01	·32	·01
	473	21 13·35	−·06	−·14	+·11	+·06	−·02	13·30	20 58·96	·34	+·01
	λ Ophiuchi	26 18·25	−·06	+·02	+·11	+·06	−·02	18·36	26 04·02	·34	+·01
	230	31 16·01	−·06	−·68	+·15	+·07	−·03	15·46	31 01·09	·37	+·04

$a = +{}^{s}\cdot796 \qquad c = +{}^{s}\cdot109$

Chronometer correction at $15^h\ 48^m = -14^s\cdot330 \pm {}^s\cdot009$

TRANSIT OBSERVATIONS.

Station : FANNING ISLAND. Date, June 3rd, 1903. Observer : F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r=+ 10	s.		h. m. s.	s.	s.
E	179............	13 29 59·75	+·01	+·05	+·12	-·07	-·02	59·84	13 29 47·27	-12·57	+·09
	m Virginis......	36 46·04	+·01	+·14	+·12	·06	-·02	46·23	36 33·67	·56	+·08
	180............	42 53·82	+·01	-·16	+·13	-·05	-·02	53·73	42 41·29	·44	-·04
	588............	44 50·78	+·01	+·25	+·13	-·04	-·02	51·11	44 38·65	·46	-·02
	182............	50 18·68	+·01	·18	+·13	-·03	-·02	18·59	50 06·12	·47	-·01
	457............	57 01·46	+·01	·30	+·14	-·02	-·02	01·27	56 48·74	·53	+·05
	π Hydræ........	14 01 05·62	-·01	-·36	+·14	-·01	-·02	06·10	14 00 53·74	·36	-·12
W	186...........	11 10·77	-·04	+·10	-·12	·00	-·02	10·69	10 58·15	·54	+·06
	188............	12 57·15	-·05	-·64	-·18	·00	-·03	56·25	12 43·84	·41	·07
	191............	23 27·39	-·04	+·06	-·12	+·02	-·02	27·29	23 14·78	·51	+·03
	192............	27 54·11	-·05	-·34	-·14	+·03	-·02	53·59	27 41·19	·40	-·08
	196............	38 11·95	·04	+·10	-·12	+·05	-·02	11·92	37 59·47	·45	-·03
	ε² Boötis..	41 00·34	-·05	-·29	-·13	+.05	-·02	59·90	40 47·34	·56	+·08
	463............	51 53·68	·05	-·12	-·13	+·07	-·02	53·43	51 40·92	.51	+·03

$a=+^{s}\cdot649$ $c=+^{s}\cdot121$

Chronometer correction at $14^{h}\ 10^{m}=-12^{s}\cdot484\pm^{s}\cdot013$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	199............	14 58 32·77	-·05	·52	-·05	-·04	-·03	32·08	14 58 19·78	-12·30	-·08
	465............	15 00 32·58	·05	-·30	-·05	-·03	-·02	32·13	15 00 19·68	·45	+·07
	592............	06 56·74	·04	+·28	-·04	-·02	-·02	56·90	06 44·48	·42	-·04
	201............	11 50·80	-·05	-·39	-·05	-·01	-·03	50·27	11 37·87	·40	+·02
	o² Libræ........	17 52·30	-·04	+·22	-·04	·00	-·02	52·42	17 40·08	·34	-·04
E	468............	21 32·36	+·02	-·14	+·04	·00	-·02	32·26	21 19·94	·32	-·06
	469............	34 35·88	+·02	-·53	+·05	+·02	-·03	35·41	34 22·99	·42	+·04
	210............	35 58·65	+·02	-·45	+·05	+·03	-·03	58·27	35 45·90	·37	-·01
	211............	38 55·19	+·02	·22	+·05	+·03	-·02	55·05	38 42·62	·43	-·05
	213............	41 57·59	+·02	-·14	+·04	+·04	-·02	57·53	41 45·18	·35	-·03
	215..........	44 37·40	+·02	-·17	+·05	+·04	-·02	37·32	44 24·92	·40	+·02

$a=+^{s}\cdot656$ $c=+^{s}\cdot043$

Chronometer correction at $15^{h}\ 19^{m}=-12^{s}\cdot377\pm^{s}\cdot011$

TRANSIT OBSERVATIONS.

Station : FANNING ISLAND. Date, June 8th, 1903. Observer : F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = - ·10	s.		h. m. s.	s.	s.
E	182	13 50 10·01	+ ·02	- ·10	+ ·02	- ·07	- ·02	09·86	13 50 06·08	03·78	·09
	457	56 52·72	+ ·02	·17	+ ·02	- ·06	- ·02	52·51	56 48·70	·81	- ·06
	458	14 06 04·80	+ ·03	- ·15	+ ·02	- ·04	- ·02	04·64	14 05 60·65	·99	+ ·12
	186	11 01·97	+ ·03	+ ·06	+ ·02	·03	- ·02	02·03	10 58·13	90	+ ·03
	188	12 48·09	+ ·03	- ·36	+ ·02	- ·03	·03	47·72	12 43·78	·94	+ ·07
	194	36 16·26	+ ·03	- ·08	+ ·02	+ ·01	- ·02	16·22	36 12·40	·82	·05
W	463	51 44·77	- ·01	- ·07	- ·02	+ ·03	- ·02	44·68	51 40·92	·76	·11
	199	58 23·92	- ·01	·29	- ·02	+ ·05	- ·02	23·63	58 19·75	·88	+ ·01
	465	15 00 23·64	- ·01	- 17	·02	+ ·05	- ·03	23·46	15 00 19·67	·79	- ·08
	592	06 48·14	- ·01	+ ·15	- ·02	+ ·06	- ·02	48·30	06 44·50	·80	·07
	466	10 28·54	·00	·01	·02	+ ·07	- ·02	28·56	10 24·62	·94	+ ·07
	201	11 42·12	·00	- ·22	- ·02	+ ·07	- ·03	41·92	11 37·86	04·06	+ ·19
	o^2 Libræ	17 43·75	·00	+ ·12	- ·02	+ ·08	- ·02	43·91	17 40·07	03·84	- ·03

$a = +^{s}\cdot368$ $c = +^{s}\cdot015$

Chronometer correction at $14^h\ 30^m = -3^s\cdot866 \pm {}^s\cdot021$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	202	15 20 55·97	+ ·06	- ·34	- ·03	- ·06	- ·03	55·57	15 20 51·87	-03·70	·01
	ζ^1 Libræ	22 53·75	+ ·06	+ ·18	- ·03	- ·06	- ·02	53·88	22 50·11	·77	+ ·06
	206	27 33·16	+ ·06	- ·39	·03	- ·04	- ·03	32·73	27 29·04	·69	- ·02
	207	28 25·19	+ ·06	- ·39	- ·03	- ·04	- ·02	24·77	28 21·15	·62	·09
	593	30 12·60	+ ·06	+ ·16	- ·03	- ·03	- ·02	12·74	30 08·93	·81	+ ·10
	469	34 27·07	+ ·06	- ·39	- ·03	- ·03	- ·02	26·63	34 23·00	·66	- ·05
	213	41 49·02	+ ·06	·10	- ·03	- ·02	- ·02	48·91	41 45·19	·72	+ ·01
E	σ Scorpii	16 15 24·13	+ ·10	+ ·26	+ ·03	+ ·04	- ·02	24·54	16 15 20·87	·67	·04
	225	17 44·88	+ ·09	- ·14	+ ·03	+ ·04	- ·02	44·88	17 41·05	·83	+ ·12
	473	21 02·62	+ ·09	- ·09	+ ·03	+ ·05	- ·02	02·68	20 58·95	·73	+ ·02
	227	26 07·70	+ ·09	+ ·01	+ ·03	+ ·06	- ·02	07·87	26 04·06	·81	+ ·10
	τ Scorpii	29 57·09	+ ·10	+ ·29	+ ·03	+ ·06	- ·02	57·55	29 54·05	·50	- ·21
	597	31 55·40	+ ·09	+ ·12	+ ·03	+ ·07	- ·02	55·69	31 52·00	·69	- ·02

$a = +^{s}\cdot488$ $c = +^{s}\cdot026$

Chronometer correction at $15^h\ 50^m = -3^s\cdot706 \pm {}^s\cdot018$

TRANSIT OBSERVATIONS.

Station: FANNING ISLAND. Date, June 9th, 1903. Observer: F. W. O. WERRY.

Clamp	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·06	s.		h. m. s.	s.	s.
E	458.	14 06 03·32	+ ·07	− ·21	− ·10	·05	02	03·21	14 06 00·61	−02·57	·02
	188.	12 46·74	+ ·08	− ·51	− ·12	− 04	03	46·36	12 43·76	·60	+ ·01
	192.	27 43·81	+ ·12	− ·27	− ·10	·03	− ·02	43·71	27 41·15	·56	− ·03
	194.	36 14·99	+ ·12	·12	− ·09	− ·02	02	15·04	36 12·40	·64	− ·05
	463.	51 43·41	+ ·12	− ·10	− ·09	− ·01	·02	43·49	51 40·92	·57	− ·02
W	592.	15 06 46·84	+ ·06	·22	·09	− ·01	·02	47·02	15 06 44·50	·52	− ·07
	466.	10 27·30	+ ·10	·01	− ·09	− 01	02	27·29	10 24·62	·67	− ·08
	201.	11 40·85	·16	·31	·10	− ·01	·03	40·52	11 37·85	·67	− ·08
	202.	20 54·79	·11	− ·36	·11	− ·02	− ·03	54·42	20 51·87	·55	− ·04
	205.	23 54·89	+ ·11	·26	·10	− ·02	− ·02	54·64	23 52·15	·49	·10
	215.	44 27·74	+ ·12	− ·14	− ·09	− ·04	·02	27·65	44 24·93	·72	+ ·13
	218.	52 03·57	+ ·12	·11	·09	+ ·05	− ·02	03·52	52 00·96	·56	− ·03

$a = +^{s}\!\cdot518$ $c = +^{s}\!\cdot088$

Chronometer correction at $15^{h}\ 00^{m} = -2^{s}\!\cdot589 \pm \cdot015$

Clamp	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
						s. r = + ·07					
W	219.	15 53 39·59	+ ·13	·24	− ·06	− ·03	− ·02	39·37	15 53 36·75	−02·62	+ ·13
	595.	59 53·07	+ ·13	·23	·05	− ·03	− ·02	53·33	59 50·89	·44	− ·05
	221.	16 05 48·14	·14	− ·51	− ·07	·01	− ·03	47·66	16 05 45·26	·40	− ·09
	222.	09 21·00	·13	− ·07	·05	− ·01	− ·02	21·12	09 18·55	·57	+ ·08
	σ Scorpii	15 23·02	·13	+ ·29	− ·05	·00	− ·02	23·37	15 20·87	·50	+ ·01
	225.	17 43·55	− ·13	− ·15	·05	·00	− ·02	43·46	17 41·05	·41	− ·08
E	231.	37 42·82	+ ·16	·30	+ 06	+ ·02	− ·02	42·74	37 40·34	·40	− ·09
	232.	39 39·51	+ ·16	− ·40	+ ·06	·02	− ·03	39·32	39 36·79	·53	+ ·04
	ε Scorpii	43 58·25	+ ·15	+ ·41	+ ·06	+ ·03	− ·03	58·87	43 56·45	·42	− ·07
	478.	47 44·99	+ ·16	− ·11	+ ·05	+ ·03	− ·02	45·10	47 42·54	·56	+ ·07
	235.	53 09·66	+ ·15	·05	− ·05	− ·04	− ·02	09·83	53 07·31	·52	+ ·03

$a = +^{s}\!\cdot545$ $c = +^{s}\!\cdot050$

Chronometer correction at $16^{h}\ 20^{m} = -2^{s}\!\cdot487 \pm {}^{s}\!\cdot019$

TRANSIT OBSERVATIONS.

Station: FANNING ISLAND. Date, June 10th, 1903. Observer: F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction	v.
		h. m. s.	s.	s.	s.	s. r = + ·07	s.		h. m. s.	s.	s.
E	458	14 06 01·86	+ ·07	− ·20	+ ·09	− ·06	− ·02	01·74	14 06 00·63	01·11	·10
	185	07 46·62	+ ·06	·11	·08	− ·06	− ·02	46·79	07 45·80	00·99	·02
	186	10 59 06	+ ·07	− ·08	·08	− ·05	·02	59·22	10 58 10	01·12	− ·11
	188	12 45.06	+ ·08	− ·48	− ·12	− ·05	·03	44·70	12 43·75	00 95	·06
	192	27 42 33	+ ·07	− ·26	− ·09	− ·04	− ·02	42·17	27 41·14	01 03	·02
	194	36 13·32	+ ·07	− ·11	− ·08	− ·02	− ·02	13·32	36 12·40	00·92	·09
	196	38 00·22	+ ·07	+ ·08	− ·08	− ·02	·02	00 41	37 59·46	00·95	06
W	212	15 39 33·11	+ ·61	− ·02	− ·08	·05	− ·02	33·05	15 39 32·03	01·02	·01
	213	41 46·31	+ ·01	− ·10	− ·08	·05	·02	46·17	41 45·19	00·98	·03
	215	44 26·15	+ ·01	·13	− ·08	·05	− ·02	25·98	44 24·93	01·05	+ 04
	216	46 02·54	+ ·01	·00	− ·08	·05	·02	02·50	46 01·50	01·00	− ·01
	218	52 02·12	+ ·01	− ·11	− ·08	+ ·06	− ·02	01·98	52 00·96	01·02	+ ·01

$a = +^{s}·491$ $c = +^{s}·080$

Chronometer correction at $15^{h}\ 00^{m} = -1^{s}·011 \pm {}^{s}·013$

W	595	15 59 51·69	+ ·01	+ ·33	− ·09	·03	− ·02	51·89	15 59 50·89	−01·00	+ ·10
	223	16 13 15·17	·00	+ ·12	− ·08	·02	− ·02	15·17	16 13 14·16	01·01	+ ·11
	σ Scorpii	15 21·41	·00	+ ·42	·09	·01	− ·02	21·71	15 20·88	00 83	− ·07
	225	17 42 27	·01	− ·22	− ·09	− ·01	− ·02	41·92	17 41 05	00·87	− ·03
	596	23 31·49	− ·02	+ ·44	− ·09	·01	− ·02	31·79	23 30·92	00·87	− ·03
	228	26 06 80	− 02	− ·26	·09	·00	− ·02	06·41	26 05·58	00·83	− ·07
E	597	31 52·57	+ ·05	+ ·20	+ ·08	·00	− ·02	52·88	31 52·01	00·87	− ·03
	231	37 41·58	+ ·06	·43	+ ·10	+ ·01	− ·02	41·30	37 40·35	00·95	+ ·05
	478	47 43·46	+ ·06	− ·16	+ ·09	+ 02	− ·02	43·45	47 42 54	00 91	+ ·01
	233	53 08·10	+ ·06	·08	+ ·08	+ 02	− ·02	08·16	53 07·32	00·84	− ·06
	234	56 38·44	+ ·07	− ·42	+ ·10	+ ·02	− ·02	38·19	56 37·31	00·88	·02

$a = +^{s}·787$ $c = +^{s}·083$

Chronometer correction at $16^{h}\ 30^{m} = -0^{s}·896 \pm {}^{s}·014$

TRANSIT OBSERVATIONS.

Station : Fanning Island. Date, June 15th, 1903. Observer : F. W. O. Werry.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = + ·015	s.		h. m. s.	s.	s.
E	457	13 56 42·37	·05	– ·30	+ ·04	– ·02	– ·02	42 02	13 56 48·62	+06·60	+ ·09
	π Hydræ	14 00 46·73	– ·05	+ ·36	+ ·04	– ·02	– ·02	47·04	14 00 53·67	·63	+ ·06
	185	07 38·99	·05	+ ·16	+ ·04	– ·02	– ·02	39·10	07 45·77	·67	+ ·02
	188	12 37·61	– ·02	– ·64	+ ·06	·02	– ·03	36·96	12 43·67	·71	·02
	192	27 34·76	+ ·01	– ·34	+ ·05	·01	– ·02	34·45	27 41·10	·65	+ ·04
	196	37 52·49	+ ·03	+ ·10	+ ·04	– ·01	– ·02	52 63	37 59·44	·81	·12
	ε² Boötis	40 40·75	+ ·03	– ·29	+ ·04	– ·01	– ·02	40·50	40 47·29	·79	– ·10
W	463	51 34·32	·02	– ·12	·04	00	– ·02	34·12	51 40·89	·77	– ·08
	199	58 13 62	·02	– ·51	– ·05	·00	– ·03	13·01	58 19·68	·67	+ ·02
	465	15 00 13·32	– ·02	– ·29	– ·04	·00	– ·02	12·95	15 00 19·63	·68	+ ·01
	222	16 09 11·84	– ·02	+ ·08	– ·04	·00	– ·02	11·84	16 09 18·57	·73	– ·04
	223	13 07·57	– ·02	+ ·10	·04	+ ·01	– ·02	07·60	13 14·18	·58	+ ·11
	σ Scorpii	15 13·89	·02	+ ·35	– ·04	+ ·02	– ·02	14·18	15 20·90	·72	– ·03
	225	17 34·65	– ·02	– ·18	– ·04	+ ·02	– ·02	34·41	17 41·05	·64	+ ·05

$a = +^{s}·648$ $c = +^{s}·039$

Chronometer correction at $15^{h}\ 10^{m} = +6^{s}·689 \pm {}^{s}·015$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	228	16 25 59·25	+ ·08	– ·24	– ·09	– ·01	– ·02	58·97	16 26 05·59	+06·62	+ ·10
	τ Scorpii	29 47·01	+ ·07	+ ·44	– ·10	– ·01	– ·02	47·39	29 54·10	·71	+ ·01
	597	31 45·31	+ ·06	+ ·18	– ·09	– ·01	– ·02	45·43	31 52·03	·60	+ ·12
	231	37 34·04	+ ·07	– ·40	– ·10	– ·01	– ·02	33·58	37 40·36	·78	– ·06
	232	39 30 70	+ ·07	– ·54	·11	– ·01	– ·03	30·08	39 36·79	·71	+ ·01
	ε Scorpii	43 49·26	+ ·06	+ ·55	– ·10	·00	– ·03	49·74	43 56·50	·76	·04
	30 Ophiuchi	55 52·82	+ ·06	+ ·10	– ·09	·00	– ·02	52·87	55 59·73	·86	– ·14
E	237	17 10 09·54	+ ·09	– ·14	+ ·09	·00	– ·02	09·56	17 10 16·20	·64	+ ·08
	239	11 36·32	+ ·09	·50	+ ·11	·00	– ·03	35·99	11 42·76	·77	– ·05
	σ Ophiuchi	21 38·06	+ ·09	·00	+ ·09	+ ·01	– ·02	38·23	21 44·99	·76	– ·04
	241	30 21·96	+ ·09	– ·11	+ ·09	+ ·01	– ·02	22·02	30 28·68	·66	+ ·06
	600	31 57·97	+ ·09	+ ·25	+ ·09	+ ·01	– ·02	58·39	32 05·10	·71	+ ·01
	245	38 36·79	+ ·09	– ·01	+ ·09	+ ·01	– ·02	36·95	38 43·70	·75	– ·03

$a = +^{s}·735$ $c = +^{s}·085$

Chronometer correction at $17^{h}\ 00^{m} = +6^{s}·719 \pm {}^{s}·015$

TRANSIT OBSERVATIONS.

Station: Fanning Island. Date, June 21st, 1903. Observer: F. W. O. Werry.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = + ·03	s.		h. m. s.	s.	s.
E	463	14 51 26·16	+ ·05	− ·08	+ ·02	·01	·02	26·12	14 51 40·85	+14·73	− ·06
	465	15 00 05·62	+ ·05	− ·20	+ ·02	·01	·02	04·86	15 00 19·59	·73	·06
	592	06 29·57	+ ·05	+ ·18	+ ·02	·01	·02	29·79	06 44·47	·68	·11
	466	10 09·63	+ ·05	− ·01	+ ·02	·01	·02	09·66	10 24·59	·93	·14
	201	11 23·21	+ ·05	− ·26	+ ·02	·00	·03	22·99	11 37·76	·77	·02
	o^2 Libræ	17 24·99	+ ·05	+ ·14	+ ·02	·00	·02	25·18	17 40·06	·88	·09
	202	20 37·30	+ ·05	− ·30	+ ·02	·00	− ·03	37·04	20 51·77	·73	− ·06
	ζ^1 Libræ	22 35·01	+ ·05	+ ·16	+ ·02	·00	·02	35·22	22 50·10	·88	− ·09
W	593	29 54·14	+ ·02	+ ·14	− ·02	·00	·02	54·26	30 08·92	·66	·13
	469	34 08·44	+ ·03	− ·34	− ·02	+ ·01	·03	08·09	34 22·92	·83	·04
	211	38 27·91	+ ·03	− ·19	− ·02	− ·01	·02	27·72	38 42·59	·87	− ·08
	213	41 30·47	·02	− ·09	− ·02	+ ·01	·02	30·37	41 45·17	·80	·01
	594	54 24·03	+ ·03	+ ·21	− ·02	− ·02	− ·02	24·25	54 39·04	·79	·00

$a =$ [illegible] ·434 $c =$ [illegible] ·015

Chronometer correction at $15^h\ 20^m = +14^s·792 \pm$ [illegible] ·017

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	595	15 59 35·92	+ ·02	+ ·18	− ·03	− ·02	− ·02	36·05	15 59 50·92	+14·87	·04
	221	16 05 30·75	+ ·02	·39	− ·03	− ·02	− ·03	30·30	16 05 45·23	·93	− ·10
	222	09 03·75	+ ·03	+ ·05	− ·03	− ·02	− ·02	03·76	09 18·58	·82	+ ·01
	223	12 59·41	+ ·03	+ ·06	·03	·02	− ·02	59·43	13 14·19	·76	+ ·07
	σ Scorpii	15 05·82	+ ·05	+ ·23	− ·03	− ·01	− ·02	06·04	15 20·91	·87	− ·04
	225	17 26·50	+ ·06	− ·12	− ·03	− ·01	− ·02	26·38	17 41·06	·68	+ ·15
E	232	39 22·19	+ ·08	− ·31	+ ·04	·00	− ·03	21·97	39 36·79	·82	+ ·01
	479	17 00 40·71	+ ·08	− ·07	+ ·03	+ ·01	− ·02	40·74	17 00 55·59	·85	− ·02
	480	04 25·01	+ ·08	− ·33	+ ·04	+ ·01	− ·03	24·78	04 39·54	·76	+ ·07
	239	11 28·15	+ ·07	− ·29	+ ·04	+ ·02	− ·03	27·96	11 42·77	·81	+ ·02
	599	15 51·48	+ ·07	+ ·22	+ ·03	+ ·02	− ·02	51·80	16 06·57	·77	+ ·06
	σ Ophiuchi	21 29·98	+ ·07	·00	+ ·03	+ ·02	− ·02	30·08	21 45·06	·98	− ·15
	600	31 50·03	+ ·07	+ ·14	+ ·03	+ ·02	− ·02	50·27	32 05·15	·88	·05

$a = +^s·420$ $c = +^s·030$

Chronometer correction at $16^h\ 40^m = +14^s·832 \pm {}^s·016$

TRANSIT OBSERVATIONS.

Station : FANNING ISLAND. Date, June 23rd, 1903. Observer : F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = + ·06	s.		h. m. s.	s.	s.
E	192	14 27 23·72	+ ·05	− ·26	− ·05	− ·09	− ·02	23·35	14 27 41·01	+17·66	+ ·11
	[illegible] Bootis	40 29·74	+ ·04	·22	− ·05	− ·08	− ·02	29·41	40 47·22	·81	− ·04
	590	45 15·56	+ ·04	+ ·17	− ·04	− ·07	− ·02	15·64	45 33·46	·82	− ·05
	225	16 17 23·15	+ ·04	·14	− ·04	+ ·02	·02	23·31	16 17 41·06	·75	+ ·02
	473	20 41·38	+ ·05	− ·09	− ·04	+ ·02	− ·02	41·30	20 59·12	·82	− ·05
	596	23 12·91	+ ·04	+ ·28	− ·04	+ ·02	·02	13·19	23 30·97	·78	− ·01
W	τ Scorpii	29 36·03	·00	+ ·30	+ ·05	+ ·03	− ·02	36·39	29 54·13	·74	+ ·03
	597	31 34·25	·00	− ·12	+ ·04	+ ·03	− ·02	34·42	31 52·06	·64	+ ·13
	231	37 22·69	+ ·01	·27	+ ·05	+ ·04	·02	22·50	37 40·35	·85	− ·08
	232	39 19·22	+ ·02	− ·37	+ ·05	+ ·04	− ·03	18·93	39 36·78	·85	·08
	ε Scorpii	43 38·20	+ ·02	+ ·37	+ ·05	+ ·04	·03	38·65	43 56·54	·89	− ·12
	233	52 49·73	+ ·02	·05	+ ·04	+ ·05	·02	49·77	53 07·38	·61	+ ·16

$a = +^{s}\cdot501 \qquad c = -^{s}\cdot041$

Chronometer correction at $16^{h}\ 00^{m} = +17^{s}\cdot767 \pm {}^{s}\cdot019$

TRANSIT OBSERVATIONS.

Station: Fanning Island. Date, June 24th, 1903. Observer: F. W. O. Werry.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·08	s.		h. m. s.	s.	s.
W	205	15 23 32·84	+ ·02	− ·22	− ·09	+ ·04	− ·02	32·57	15 23 52·07	+19·50	+ ·03
	206	27 09·74	+ ·02	− ·35	− ·11	+ ·03	− ·03	09·30	27 28·91	·61	− ·08
	593	29 49·39	+ ·02	+ ·14	− ·08	+ ·03	− ·02	49·48	30 08·91	·43	+ ·10
	469	34 03·83	+ ·02	− ·34	− ·11	·02	− ·03	03·39	34 22·89	·50	+ ·03
	211	38 23·24	·02	− ·18	− ·09	+ ·02	− ·02	22·99	38 42·59	·60	− ·07
E	218	51 41·44	+ ·09	− ·09	·09	·00	− ·02	41·51	52 00·93	·42	+ ·11
	595	59 31·04	+ ·09	+ ·18	+ ·09	·01	− ·02	31·37	59 50·92	·55	− ·02
	222	16 08 58·79	+ ·09	− ·06	+ ·08	·02	− ·02	58·98	16 09 18·57	·59	− ·06
	σ Scorpii	15 00·98	+ ·09	+ ·23	·09	·03	− ·02	01·34	15 20·92	·58	− ·05
	225	17 21·55	+ ·09	− ·12	+ ·09	− ·03	− ·02	21·56	17 41·06	·50	+ ·03

$a = + {}^{s}\cdot430$ $c = + {}^{s}\cdot082$

Chronometer correction at $15^h\ 50^m = +19^s\cdot530 \pm {}^s\cdot018$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
E	473	16 20 39·49	+ ·67	− ·09	+ ·14	·05	− ·02	39·64	16 20 59·11	+19·47	− ·04
	τ Scorpii	29 34·17	+ ·06	+ ·29	+ ·16	+ ·04	− ·02	34·70	29 54·13	·43	·00
	597	31 32·39	+ ·05	+ ·12	+ ·14	+ ·04	− ·02	32·72	31 52·06	·34	+ ·09
	232	39 17·45	+ ·07	·36	+ ·18	+ ·03	·03	17·34	39 36·78	·44	·01
	ε Scorpii	43 36·49	+ ·07	+ ·36	+ ·17	+ ·02	− ·03	37·08	43 56·54	·46	− ·03
	478	47 23·09	+ ·07	·10	+ ·15	+ ·02	− ·02	23·21	47 42·59	·38	+ ·05
	233	52 47·73	+ ·07	·05	+ ·14	+ ·01	− ·02	47·88	53 07·38	·50	·07
W	234	56 18·39	+ ·03	·26	− ·16	+ ·01	·02	17·99	56 37·33	·34	+ ·09
	599	17 15 47·23	+ ·02	+ ·26	·15	− ·02	− ·02	47·32	17 16 06·59	·27	+ ·16
	σ Ophiuchi	21 25·67	+ ·03	·00	·14	·03	− ·02	25·51	21 45·05	·54	·11
	241	30 09·56	+ ·02	·07	− ·14	− ·04	− ·02	09·31	30 28·73	·42	+ ·01
	600	31 45·69	+ ·02	+ ·16	·15	− ·04	− ·02	45·66	32 05·18	·52	·09
	245	38 24·42	+ ·03	·00	− ·14	− ·05	− ·02	24·24	38 43·77	·53	− ·10

$a = + {}^{s}\cdot485$ $c = + {}^{s}\cdot140$

Chronometer correction at $17^h\ 00^m = +19^s\cdot433 \pm {}^s\cdot017$

TRANSIT OBSERVATIONS.

Station: SUVA. Date, June 3rd, 1903. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	r = ·15 s.	s.		h. m. s.	m. s.	s.
E	β Chamæleontis	12 16 25·58	−·19	−10·62	−·96	−·11	·10	13·82	12 12 45·92	−3 27·90	−·02
	δ² Corvi	28 20·92	·08	+·10	−·20	−·08	−·02	20·80	24 52·88	·92	·00
	ρ Virginis	40 27·45	−·07	+1·16	−·19	−·05	−·02	28·38	36 60·46	·92	·00
	35 Virginis	46 24·41	·07	+·90	−·19	−·04	−·02	25·07	42 57·10	·97	−·05
	31 Comæ	50 26·52	−·06	+1·85	−·21	−·03	−·02	28·11	46 60·31	·80	−·12
	δ Virginis	54 12·39	·07	+·90	·19	−·02	−·02	13·63	50 45·11	·92	·00
	ε Virginis	13 00 49·94	−·07	+1·19	−·19	·00	−·02	50·85	57 22·94	·91	−·01
W	γ Hydræ	17 09·59	·17	·21	−·20	−·04	·02	09·35	13 13 41·45	·90	·02
	ι Centauri	18 40·28	−·19	·90	+·23	−·04	−·02	39·36	15 11·47	·89	−·03
	α Virginis	23 35·05	·16	−·31	−·19	−·05	·02	35·32	20 07·36	·96	+·04
	ζ Virginis	33 14·67	·15	+·74	−·19	·08	−·02	15·35	29 47·32	28·03	·11
	ε Centauri	37 18·29	·21	−2·16	−·30	−·09	−·03	16·10	33 48·30	27·80	−·12
	m Virginis	40 01·37	·16	+·40	−·19	−·10	−·02	01·68	36 33·67	28·01	−·09
	τ Boötis	46 07·89	−·14	+1·47	−·20	−·11	−·02	09·29	42 41·33	27·96	+·04

$a = -2^{s}\cdot376 \qquad c = -^{s}\cdot188$

Chronometer correction at $13^{h}\ 1^{m} = -3^{m}\ 27^{s}\cdot921 \pm {}^{s}\cdot013$

TRANSIT OBSERVATIONS.

Station: SUVA. Date, June 4th, 1903. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = −·17	s.		h. m. s.	m. s.	s.
E	ε Virginis. . . .	13 00 51·52	−·01	+2·50	−·21	+·10	−·02	53·88	12 57 22·93	−3 30·95	·06
	θ Virginis.	08 27·89	−·01	+1·15	−·21	+·09	−·02	28·89	13 04 57·87	31·02	+·01
	γ Hydræ.	17 13·06	−·01	−·45	−·22	+·06	−·02	12·42	13 41·44	30·98	·03
	ι Centauri. . . .	18 44·67	−·01	−1·90	−·26	+·05	−·02	42·53	15 11·46	31·07	+·06
	ζ Virginis.	33 16·93	−·01	+1·55	−·21	+·01	−·02	18·25	29 47·31	30·94	·07
	ε Centauri.	37 24·30	−·01	−4·54	−·33	·00	−·03	19·39	33 48·28	31·11	+·10
	m Virginis.	40 04·03	−·01	+·85	−·21	−·01	−·02	04·63	36 33·66	30·97	·04
W	τ Boötis	46 09·17	·00	+3·10	+·22	−·03	−·02	12·44	42 41 32	31·12	+·11
	ζ Centauri.	53 07·07	·00	−3·50	+·30	−·05	−·03	03·79	49 32·87	30·92	·09
	τ Virginis.	14 00 14·20	·00	+1·70	+·21	−·07	−·02	16·02	56 44·98	31·04	+·03
	π Hydræ.	04 25·35	·00	−·75	+·23	−·08	−·02	24·73	14 00 53·74	30·99	−·02
	κ Virginis. . . .	11 16·10	·00	+·75	+·21	−·10	−·02	16·94	07 45·85	31·09	+·08
	α Boötis.	14 44·06	·00	+3·25	+·22	−·10	−·02	47·41	11 16·43	30·98	·03

$a = +5^s{\cdot}011 \qquad c = -^s{\cdot}209$

Chronometer correction at $13^h\ 37^m = -3^m\ 31^s{\cdot}014 \pm {}^s{\cdot}014$

W	β Libræ.	15 15 20·36	+·03	+·80	+·18	+·13	−·02	21·48	15 11 49·99	−3 31·49	+·13
	ξ¹ Libræ.	26 21·09	+·03	+·15	+·19	+·09	−·02	21·53	22 50·10	·43	+·07
	γ Lupi.	32 17·85	+·03	−2·56	+·23	+·08	−·03	15·60	28 44·37	·23	·13
	α Coronæ.	34 04·39	+·02	+3·97	+·20	+·07	−·02	08·63	30 37·31	·32	·04
	α Serpentis. . . .	43 01 08	+·02	+2·11	+·18	+·05	−·02	03·42	39 32·05	·37	+·01
	μ Serpentis. . . .	48 06·12	+·02	+1·41	+·18	+·03	−·02	07·74	44 36·24	·50	+·14
	β Triang. Aust.	50 20·18	+·04	−7·73	+·39	+·03	−·04	12·87	46 41·56	·31	·05
E	δ Scorpii.	58 10·82	+·09	−·40	·19	·01	−·02	10·31	54 39·02	·29	·07
	β¹ Scorpii	16 03 22·51	+·09	−·15	−·19	−·01	−·02	22·23	59 50·87	·36	·00
	γ² Normæ	16 14·88	+·11	−4·07	−·28	−·03	−·03	10 58	16 12 39 19	·39	+·03
	γ Herculis.	21 09·28	−·07	+3·26	−·19	−·06	−·02	12·34	17 41 05	·29	·07
	α Scorpii.	27 03·17	+·09	−·80	·20	−·08	−·02	02·16	23 30·90	·26	·10
	λ Ophiuchi	29 33.83	+·08	+1·76	·18	·08	−·02	35·39	26 04·01	·38	+·02
	α Triang. Aust.	42 13·38	+·15	−10·75	−·49	·12	−·06	02·11	38 30 67	·44	+·08

$a = 5^s{\cdot}022 \qquad c = -^s{\cdot}178$

Chronometer correction at $16^h\ 00^m = -3^m\ 31^s{\cdot}361 \pm {}^s{\cdot}014$

TRANSIT OBSERVATIONS.

Station : SUVA. Date, June 9th, 1903. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·12	s.		h. m. s.	m. s.	s.
E	γ Crucis......	12 29 34·71	+ ·06	+ ·75	− ·34	+ ·09	·04	35·23	12 25 50·20	−3 45·03	− ·06
	β Corvi........	33 04·73	+ ·06	+ ·06	21	+ 08	02	04 70	29 19 71	44 99	·02
	γ Virginis......	40 45·83	+ ·06	− ·32	19	+ 07	02	45·43	37 00 40	45 03	·06
	β Crucis.......	45 50 97	+ ·13	+ ·85	37	+ ·06	04	51 60	42 06 70	44 90	07
	δ Virginis.....	54 30·24	+ ·11	25	·19	+ 04	02	29 93	50 45 06	44·87	10
	ε Virginis......	13 01 08·23	+ ·12	− ·33	19	+ ·03	02	07 84	57 22·89	44 95	·02
	θ Virginis.....	08 43·04	+ ·15	− ·15	19	+ ·01	02	42 84	13 04 57 83	45 01	·04
W	γ Hydræ......	17 26·05	+ ·11	+ ·08	21	01	02	26 42	13 41 40	45 02	·05
	α Virginis.....	23 52·21	+ ·10	− ·11	·19	02	·02	52 35	20 07 32	45·03	+ ·06
	ζ Virginis.....	33 32·36	+ ·10	− ·27	·19	04	02	32 32	29 47·28	45 04	07
	ε Centauri.....	37 32·08	+ ·13	+ ·78	30	05	·03	33 21	33 48 21	45·00	·03
	τ Virginis. ...	14 00 30·06	+ ·09	− ·29	19	09	02	29 94	56 44 95	44 99	02
	π Hydræ.....	04 38·31	+ ·11	+ ·13	·21	10	·02	38 64	14 00 53 72	44·92	05
	κ Virginis.....	11 30·74	+ ·10	− ·13	·19	12	02	30 76	07 45 83	44 93	·04

$a_2 = +^s{\cdot}855 \qquad a_1 = +^s{\cdot}663 \qquad c = -^s{\cdot}190$

Chronometer correction at $13^h\ 14^m = -3^m\ 44^s{\cdot}971 \pm {}^s{\cdot}014$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	β Libræ	15 15 35 10	11	·12	·14	+ ·19	− ·02	35 40	15 11 50 00	−3 45·40	·01
	ζ Libræ	26 35 25	+ 11	·02	·14	+ ·17	− ·02	35 63	22 50·11	·52	+ 13
	γ Lupi........	32 28·86	+ ·14	·39	·18	+ ·16	− ·03	29 70	28 44·39	·31	08
	ω[1] Scorpii.. ...	16 03 35 85	+ ·12	02	+ ·15	+ ·09	− ·02	36 21	59 50·90	·31	·08
	δ Ophiuchi....	13 03·79	+ 11	19	+ ·14	+ ·07	− ·02	03 90	16 09 18 56	·34	·05
	γ[2] Normæ	16 23 66	+ 14	+ ·63	+ ·21	+ ·07	− ·03	24 68	12 39 24	·44	·05
E	λ Scorpii.......	17 30 50 00	·41	·32	17	08	− ·03	50 45	17 27 05 06	·39	·00
	η Pavonis. ...	40 02·93	+ ·56	+1 31	·32	·10	− ·05	04 33	36 18·95	·38	− ·01
	β Ophiuchi....	42 29 33	·30	30	14	10	− ·02	29 07	38 43 66	·41	+ 02
	μ Herculis.....	46 28·40	+ ·28	·63	15	·11	− 02	27·77	42 42 38	·39	·00
	89 Herculis....	55 19 10	28	·60	15	13	− ·02	18 48	51 33 10	·38	·01
	ν Ophiuchi....	57 29 69	+ ·35	·12	14	14	− ·02	29 62	53 44·19	·43	·04

$a = +^s{\cdot}777 \qquad c = -^s{\cdot}140$

Chronometer correction at $16^h\ 50^m = -3^m\ 45^s{\cdot}392 \pm {}^s{\cdot}013$

TRANSIT OBSERVATIONS.

Station: Suva. Date, June 10th, 1903. Observer: Otto Klotz.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = −·15	s.		h. m. s.	m. s.	s.
E	β Chamæleontis	12 16 30·44	+·40	+2·76	−1·02	+·11	−·10	32 59	12 12 45·31	−3 47·28	+·02
	β Corvi	33 06·89	+·17	+·06	·22	+·07	−·02	06 95	29 19·70	·25	·01
	ρ Virginis.....	40 48·00	+·14	−·30	·20	+·05	−·02	47·67	37 00·39	·28	+·02
	35 Virginis.....	46 44·55	+·15	·23	·20	+·04	−·02	44 29	42 57 03	·26	·00
	31 Comæ	50 48·14	+·13	·48	·23	+·02	·02	47·56	46 60·23	·33	+·07
	δ Virginis.....	54 32·51	+·15	·23	−·20	+·01	−·02	32·22	50 45 04	18	·08
	ε Virginis.....	13 01 10·47	+·14	·31	·20	·00	−·02	10·08	57 22·88	·20	06
W	θ Virginis ..	08 44·98	+·16	·14	+·20	·02	−·02	45 16	13 04 57·82	·34	+·08
	γ Hydræ.... ..	17 28·27	+·17	·06	+·21	·04	−·02	28 65	13 41·39	·26	00
	ι Centauri ...	18 57·96	+·19	+·23	+25	·05	−·02	58.56	15 11·40	·16	10
	α Virginis.....	23 54·42	+·16	08	+·20	06	−·02	54·62	20 07·31	·31	+·05
	ζ Virginis. ...	33 34·55	+·15	·19	+·20	·08	−·02	34·61	29 47 27	·34	+08
	m Virginis.....	40 20·74	+·16	·10	+·20	·10	−·02	20·88	36 33·63	·25	·01
	τ Boötis.......	46 28·69	+·14	·38	+·20	−·11	−·02	28 52	42 41·27	·25	·01

$a = -{}^s{\cdot}618$ $c = {}^s{\cdot}198$

Chronometer correction at $13^h\ 00^m = -3^m\ 47^s{\cdot}263 \pm {}^s{\cdot}011$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	ρ Boötis.	14 31 29 05	·05	−·74	−·27	+·10	−·03	28·70	14 27 41·16	−3 47·54	·02
	ε² Boötis.......	44 35·12	+·06	−·56	+·24	+·07	−·02	34 91	40 47·33	·58	+02
	α Libræ......	49 20 86	+·07	−·03	+·22	+·06	−·02	21·16	45 33 55	·61	+·05
	ξ² Libræ.......	55 20·46	+·07	−·09	+·21	+04	−·02	20 67	51 33 03	·64	+·08
	20 Libræ......	15 02 13·71	+·08	+·09	+·23	+·03	−·02	14 12	58 26·67	·45	11
E	β Libræ.......	15 37·57	+·29	−·11	−21	·01	−·02	37·51	15 11 50·00	·51	·05
	α Coronæ.	34 25·49	+·23	−·55	−·23	−·05	−·02	24·87	30 37·30	·57	+·01
	α Serpentis....	43 19 95	+·26	−·29	−·21	−·07	−·02	19 62	39 32·07	·55	·01
	μ Serpentis....	48 24·01	+·28	−·19	·21	·09	−·02	23 78	44 36·27	·51	−·05
	ε Serpentis. ..	49 49 42	+·28	−·16	−·21	−·09	−·02	49·22	46 01·53	·69	+13
	γ Serpentis....	55 48·97	+·25	−·40	−22	·10	−·02	48·48	51 60·95	·53	−·03

$a = -{}^s{\cdot}692$ $c = -{}^s{\cdot}209$

Chronometer correction at $15^h\ 13^m = -3^m\ 47^s{\cdot}561 \pm {}^s{\cdot}020$

TRANSIT OBSERVATIONS.

Station: Suva. Date, June 11th, 1903. Observer: Otto Klotz.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = −.14	s.		h. m. s.	m. s.	s.
E	β Chamæleontis	12 16 33·49	−·03	−2·79	−1·24	+·15	−·10	35·06	12 12 45·22	3 49·84	−·06
	δ² Corvi........	28 42·66	+·17	−·02	−·25	+·12	−·02	42·66	24 52·79	·87	+·09
	ε Virginis.....	13 01 13·06	+·15	·31	·25	+·05	−·02	12·68	57 22·87	·81	−·03
	α Virginis.....	23 57·23	+·17	−·08	−·25	+·02	−·02	57·07	13 20 07·31	·76	·02
	ε Centauri....	37 37·50	−·22	·57	·39	·03	−·03	37·84	33 48·18	·66	−·12
	m Virginis.....	40 23·57	+·17	−·11	·24	−·04	−·02	23·33	36 33·62	·71	−·07
	τ Boötis.....	46 31·57	+·14	·39	·25	·06	−·02	30·99	42 41·27	·72	−·06
W	ζ Centauri.....	53 21·72	+·10	·44	+·35	−·07	−·03	22·51	49 32·80	·71	−·07
	τ Virginis.....	14 00 34·80	+·08	·21	+·24	·09	−·02	34·80	56 44·94	·86	−·08
	θ Centauri.....	04 50·80	+·09	+·24	+·30	−·10	−·02	51·31	14 01 01·54	·77	−·01
	κ Virginis.....	11 35·56	+·08	·09	+·24	·12	−·02	35·65	07 45·82	·83	+·05
	α Boötis.......	15 06·38	+·07	·41	+·26	−·13	−·02	06·15	11 16·39	·76	·02
	f Boötis.......	25 49·02	+·07	·41	+·26	−·15	−·02	48·77	21 58·90	·87	−·09

$a = -{}^{s}\cdot 624$ $c = -{}^{s}\cdot 242$

Chronometer correction at $13^{h}\ 21^{m} = -3^{m}\ 49^{s}\cdot 782 \pm {}^{s}\cdot 015$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	ξ² Libræ......	14 55 22·72	+·25	−·09	+·19	−·12	−·02	23·17	14 51 33·03	−3 50·14	+·05
	20 Libræ.......	15 02 16·04	·27	+·09	+·21	+·10	−·02	16·69	58 26·67	·02	−·07
	ζ Boötis......	04 09·83	+·20	·58	+·21	+·10	−·02	09·74	15 00 19·69	·05	−·04
	ι¹ Libræ.	10 34·00	+·26	+·01	+·20	+·08	−·02	34·53	06 44·50	·0	−·06
	ο² Libræ.	21 29·82	+·26	·04	·20	+·06	−·02	30·28	17 40·08	·23	+·11
	ζ¹ Libræ.......	26 39·74	+·26	−·02	·20	+·05	−·02	40·21	22 50·13	·00 8	−·01
E	α Coronæ.....	34 27·83	+·32	−·57	·21	+·03	−·02	27·38	30 37·30	·08	−·01
	α Serpentis....	43 22·28	+·38	−·30	−·19	·00	−·02	22·15	39 32·07	·08	−·01
	β Triang. Aust.	50 30·38	+·66	+1·11	·42	−·01	−·04	31·68	46 41·59	·09	·00
	β¹ Scorpii......	16 03 40·84	−·43	·02	−·20	−·04	−·02	41·03	59 50·91	·12	+·03
	δ Ophiuchi.....	13 08·77	−·40	·18	·19	−·06	−·02	08·72	16 09 18·60	·12	+·03
	λ Ophiuchi.....	29 54·35	−·39	−·25	−·19	−·10	−·02	54·18	26 04·08	·10	+·01
	ζ Ophiuchi.....	35 42·15	−·41	−·10	·19	−·12	−·02	42·13	31 52·04	·09	·00

$a = +{}^{s}\cdot 721$ $c = -{}^{s}\cdot 191$

Chronometer correction at $15^{h}\ 45^{m} = -3^{m}\ 50^{s}\cdot 090 \pm {}^{s}\cdot 010$

TRANSIT OBSERVATIONS.

Station: Suva. Date, June 16th, 1903. Observer: Otto Klotz.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·10	s.		h. m. s	m. s.	s.
E	κ Virginis.	14 11 48·37	− ·04	− ·08	− ·17	− ·05	·02	48·19	14 07 45·82	− 4 02·37	·09
	α Boötis.......	15 19·27	− ·07	− ·36	− ·18	− ·05	− ·02	18·83	11 16·35	·48	− ·02
	f Boötis.......	26 01·82	− ·08	− ·36	− ·18	− ·03	− ·02	01·37	21 58·88	·49	− ·03
	ρ Boötis	31 44·25	+ ·07	− ·60	− ·22	− ·02	·03	43·49	27 41·11	·38	·08
	η Centauri.....	33 26·55	− ·10	+ ·41	− ·23	− ·02	− ·03	26·82	29 24·40	·42	− ·04
	α Circini.	38 47·14	− ·18	+ ·94	− ·39	− ·01	− ·05	47·83	34 45·34	·49	− ·03
	ϵ^2 Boötis.......	44 50·39	− ·09	·45	·19	·00	·02	49·82	40 47·28	·54	− ·08
W	α Libræ.	49 35·88	− ·01	02	− ·17	− ·01	− ·02	35·99	45 33·53	·46	00
	ξ^2 Libræ.	55 35·51	01	− ·07	− ·17	− ·02	·02	35·56	51 33·02	·54	+ ·08
	20 Libræ	15 02 28·83	− ·01	+ ·07	− ·18	− ·03	·02	29·02	58 26·65	·37	− ·09
	ψ Boötis	04 22·43	− ·01	·45	− ·19	− ·04	− ·02	22·10	15 00 19·66	·44	− ·02
	γ Triang. Aust.	13 58·45	− 02	+1·21	− ·48	·05	·06	60 01	09 57·58	·43	·03
	β Libræ.	15 52·56	− ·01	·09	− ·17	·05	− ·02	52·56	11 49·99	·57	+ ·11

$a = +^{s}·560$ $c = -^{s}·170$

Chronometer correction at $14^{h}\ 43^{m} = -4^{m}\ 02^{s}·461 \pm {}^{s}·014$

W	α Serpentis....	15 43 34·77	+ ·03	·26	+ ·20	− ·06	− ·02	34·78	15 39 32·07	− 4 02·71	+ ·11
	μ Serpentis. ...	48 38·86	+ ·03	− ·17	+ ·20	+ ·06	− ·02	38 96	44 36 28	·68	+ ·08
	β Triang. Aust.	50 42·63	+ ·05	+ ·95	+ ·43	+ ·05	− ·04	44·07	46 41·57	·50	− ·10
	γ Serpentis. ...	56 03·70	+ ·03	− ·36	+ ·20	+ ·04	− ·02	03·59	52 00·95	·64	+ ·04
	δ Scorpii.......	58 41·37	+ ·03	+ ·05	+ ·21	+ ·04	− ·02	41·68	54·39·07	·61	+ ·01
	β^1 Scorpii.......	16 03 53·35	+ ·03	+ ·02	+ ·21	+ ·03	− ·02	53 62	59 50·92	·70	+ ·10
	δ Ophiuchi.....	13 21·09	+ ·03	− ·15	+ ·20	+ ·01	− ·02	21·16	16 09 18·61	·55	− ·05
E	γ Herculis.	21 44·09	+ ·26	− ·40	− ·21	·00	− ·02	43·72	17 41·08	·64	+ ·04
	α Scorpii.......	27 33·33	+ ·34	+ ·16	− ·22	− ·01	− ·02	33·52	23 30·99	·53	− ·07
	α Triang. Aust.	42 32·29	+ ·54	+1·32	− ·54	·03	− ·06	33·52	38 30·82	·70	+ ·10
	ε Scorpii	47 58·81	+ ·36	− ·20	− ·24	− ·04	− ·02	59·07	43 56·50	·57	− ·03
	κ Ophiuchi... .	57 10·32	+ ·25	− ·38	− ·20	− ·06	− ·02	09·91	53 07·40	·51	− ·09
	30 Ophiuchi....	17 00 02·40	+ ·30	− 16	− ·20	− ·06	− ·02	02·26	55 59·73	·53	− ·07

$a = +^{s}·617$ $c = -^{s}·195$

Chronometer correction at $16^{h}\ 22^{m} = -4^{m}\ 02^{s}·605 \pm {}^{s}·016$

TRANSIT OBSERVATIONS.

Station : SUVA. Date, June 22nd, 1903. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r − ·10	s.		h. m. s.	m. s.	s.
E	γ Hydræ......	13 17 57·62	+ ·04	+ ·04	− ·20	− ·08	− ·02	57·56	13 13 41·27	−4 16·29	+ ·04
	ι Centauri	19 27·45	+ ·04	+ ·21	− ·23	− ·07	− ·02	27·52	15 11·25	·27	+ ·02
	α Virginis.....	24 23·69	+ ·04	− ·07	− ·19	− ·06	− ·02	23·51	20 07·20	·31	+ ·06
	ζ Virginis.....	34 03·73	+ ·04	− ·17	− ·19	− ·05	− ·02	03·44	29 47·16	·28	− ·03
	ε Centauri	38 03·97	+ ·05	+ ·49	− ·30	− ·04	− ·03	04·22	33 47·99	·23	− ·02
	τ Boötis......	46 57·90	+ ·03	− ·34	− ·20	− ·03	− ·02	57·40	42 41·16	·24	− ·01
	η Boötis......	54 22·70	+ ·03	− ·35	− ·20	− ·02	− ·02	22·18	50 06·01	·17	− ·08
W	β Centauri	14 01 18·23	− ·08	− ·71	+ ·38	·00	− ·04	19·20	57 02·99	·21	− ·04
	π Hydræ......	05 09·64	− ·06	+ ·08	+ ·21	·00	− ·02	09·85	14 00 53·62	·23	− ·02
	κ Virginis.. ..	12 02·02	− ·06	− ·08	+ ·19	− ·02	− ·02	02·03	07 45·76	·27	+ ·02
	f Boötis.... ..	26 15·36	− ·05	− ·35	+ ·20	− ·04	− ·02	15·10	21 58·83	·27	+ ·02
	ρ Boötis	31 57·69	− ·04	− ·58	+ ·24	− ·05	− ·03	57·23	27 41·04	·19	− ·06
	ϵ^2 Boötis..	45 03·83	− ·04	− ·44	+ ·21	− ·07	− ·02	03·47	40 47·22	·25	·00
	α Libræ	49 49·81	− ·06	− ·02	+ ·20	− ·08	− ·02	49·83	45 33·49	·34	+ ·09

a = − ·542   c = − ·189

Chronometer correction at $14^h\ 03^m = -4^m\ 16^s{\cdot}254 \pm {}^s{\cdot}009$

TRANSIT OBSERVATIONS.

Station : SUVA. Date, June 24th, 1903. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s.	s.		h. m. s.	m. s.	s.
E	31 Comæ. ..	12 51 21·14	+·12	·50	·21	+·07	−·02	20 60	12 46 60 04	−4 20 56	+·06
	δ Virginis....	55 05 62	+·14	·24	·19	+·06	−·02	05·37	50 44 90	·47	−·03
	ε Virginis.....	13 01 43 57	+·13	·32	·19	+·05	−·02	43·22	57 22·73	·49	−·01
	θ Virginis.....	09 18·34	+·14	·15	·19	+·04	−·02	18 16	13 04 57·69	·47	−·03
	γ Hydræ.. ...	18 01 68	+·16	·06	·20	+.02	−·02	01·70	13 41·25	·45	−·05
	ι Centauri ...	19 31 63	+·17	24	23	+·02	−·02	31·81	15 11 22	·59	+·09
	α Virginis ...	24 27·80	+·15	08	·19	+·01	−·02	27·67	20 07·18	49	−·01
W	ζ Virginis. .	34 07·77	·01	−·20	19	·01	−·02	07·72	29 47 15	57	+·07
	ε Centauri ...	38 07 58	·01	+·59	·30	·02	−·03	08·41	33 47 95	·46	−·04
	m Virginis .	40 53 99	·01	−·11	−·19	·02	−·02	54 02	36 33 52	50	·00
	τ Boötis......	47 01·84	01	−·40	20	·04	−·02	01·57	42 41·13	41	−·06
	ζ Centauri	53 52 51	·01	+·45	·27	−·05	−·03	53·14	49 32·62	·52	+·02
	τ Virginis	14 01 05 49	·01	−·22	·19	06	−·02	05·37	56 44·85	·52	+·02
	π Hydræ... ..	05 13·85	−·01	+·10	·21	·07	−·02	14·06	14 00 53·60	·46	−·04

$a = +{}^{s}\cdot643$ $c = -{}^{s}\cdot187$

Chronometer correction at 13^{h} 28^{m} = $-$ 4^{m} $20^{s}\cdot501 \pm {}^{s}\cdot009$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	α Boötis..... .	14 15 37 02	+·03	·33	+·20	+·09	−·02	36·99	14 11 16·27	−4 20·72	+·03
	f Boötis.......	26 19 60	+·03	·33	+·20	+·07	−·02	19 55	21 58·81	·74	+·05
	ρ Boötis.	32 01·86	−02	·54	+·24	+·06	−·03	01·61	27 41 02	·59	10
	α Circini	39 04·56	+·05	+·85	+·44	+·04	−·02	05·92	34 45·19	·73	+·04
	ε² Boötis.......	45 07·99	+·02	·41	+21	+·03	−·02	07·82	40 47·21	·61	·08
	α Libræ.... ...	49 53·98	+·03	02	+·20	+·02	−·02	54·19	45 33·49	·70	+·01
E	ξ² Libræ.	55 53·79	+·21	·07	−·19	+·01	−·02	53·75	51 32·98	.75	+·06
	20 Libræ.	15 02 47·26	+·23	+·07	·21	·00	−·02	47·33	58 26·62	·71	+·02
	ψ Boötis.......	04 40·81	+·17	−·41	·21	·01	−·02	40·33	15 00 19·60	·73	+·04
	ι¹ Libræ.	11 05 13	+·22	+·01	−·20	−·02	−·02	05·12	06 44·47	·65	−·04
	β Libræ.	16 10·83	+·21	·08	−·19	−·03	−·02	10·72	11 49·96	·76	+·07
	β Triang. Aust.	51 01·57	+·34	+·78	−·42	−·10	−·04	02·13	46 41·53	·60	−·09

$a = +{}^{s}\cdot506$ $c = -{}^{s}\cdot189$

Chronometer correction at 15^{h} 00^{m} = -4^{m} $20^{s}.691 \pm {}^{s}\cdot013$

TRANSIT OBSERVATIONS.

Station: SUVA. Date, June 25th, 1903. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	r.
		h. m. s.	s.	s.	s.	s. r = − ·12	s.		h. m. s.	m. s.	s.
E	ζ Virginis.....	13 34 10·27	+ ·07	− ·14	− ·16	+ ·08	− ·02	10·10	13 29 47·14	−4 22·96	+ ·01
	ε Centauri...	38 10·63	+ ·10	+ ·41	− ·26	+ ·07	− ·03	10·92	33 47·93	·99	+ ·04
	m Virginis.....	46 56·54	+ ·07	− ·07	− ·16	+ ·06	− ·02	56·42	36 33·51	·91	− ·04
	τ Boötis........	47 04·50	+ ·06	− ·27	− ·17	+ ·05	− ·02	04·15	42 41·13	23·02	+ ·07
	ζ Centauri.....	53 55·34	+ ·09	+ ·32	·23	+ ·04	− ·03	55·53	49 32·61	22·92	− ·03
	τ Virginis.....	14 01 08·03	+ ·07	− ·15	− ·16	+ ·02	− ·02	07·79	56 44·84	·95	·00
	π Hydræ.....	05 16·54	+ ·08	+ ·08	− ·18	+ ·01	− ·02	16·51	14 00 53·59	·92	− ·03
W	κ Virginis.....	12 08·63	− ·03	− ·08	+ ·16	·00	− ·02	08·66	07 45·72	·94	− ·01
	α Boötis......	15 39·41	− ·02	− ·30	+ ·17	− ·01	− ·02	39·23	11 16·27	·96	+ ·01
	f Boötis......	26 21·99	− ·02	− ·30	+ ·17	− ·03	− ·02	21·79	21 58·80	·99	+ ·04
	ρ Boötis......	32 04·29	− ·02	− ·47	+ ·20	− ·04	− ·03	03·93	27 41·01	·92	− ·03
	ϵ^2 Boötis......	45 10·45	− ·02	·37	+ ·18	− ·07	− ·02	10·15	40 47·19	·96	+ ·01
	α Libræ......	49 56·41	− ·03	− ·02	+ ·17	·07	− ·02	56·44	45 33·48	·96	+ ·01

$a = -^s·456$ $c = \ ^s·159$

Chronometer correction at $14^h 12^m = -4^m 22^s·952 \pm ^s·008$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	r.
W	ξ^2 Libræ....	14 55 55·93	·01	− ·07	+ ·20	+ ·11	− ·02	56·14	14 51 32·98	−4 23·16	·00
	20 Libræ......	15 02 49·38	− ·01	+ ·07	− ·21	+ ·10	− ·02	49·73	58 26·61	·12	− ·04
	ψ Boötis......	04 42·85	− ·01	− ·44	− ·22	+ ·10	− ·02	42·70	15 00 19·59	·11	− ·05
	ι^1 Libræ.....	11 07·36	− ·01	+ ·01	+ ·20	+ ·08	− ·02	07·62	06 44·46	·16	·00
	β Libræ......	16 13·02	− ·01	− ·09	+ ·19	− ·07	− ·02	13·16	11 49·95	·21	+ ·05
	ζ^1 Libræ.....	27 13·08	− ·01	− ·02	+ ·20	+ ·05	− ·02	13·28	22 50·09	·19	− ·03
E	β Triang. Aust.	51 03·96	+ ·28	− ·84	− ·43	·00	− ·04	04·61	46 41·51	·10	− ·06
	δ Scorpii......	59 02·26	+ ·19	− ·05	− ·21	− ·01	− ·02	02·26	54 39·07	·19	+ ·03
	β^1 Scorpii......	16 04 14·25	− ·19	+ ·02	− ·20	− ·02	− ·02	14·22	59 50·93	·29	+ ·13
	α Scorpii......	27 54·12	− ·19	+ ·09	− ·21	·07	− ·02	54·10	16 23 31·01	·09	− ·07
	λ Ophiuchi...	30 27·57	− ·17	− ·19	·19	− ·08	− ·02	27·26	26 04·10	·16	·00
	ζ Ophiuchi....	36 15·50	+ ·18	− ·08	− ·20	− ·09	− ·02	15·29	31 52·08	·21	+ ·05
	ε Scorpii......	48 19·63	+ ·20	+ ·18	− ·23	− ·11	− ·02	19·65	43 56·54	·11	− ·05

$a = -^s·548$ $c = -^s·192$

Chronometer correction at $15^h 52^m = -4^m 23^s·162 \pm ^s·013$

TRANSIT OBSERVATIONS.

Station : SUVA. Date, August 11th, 1903. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·094	s.		h. m. s.	s.	s.
E	η Ophiuchi	17 05 13·94	+ ·14	− ·02	− ·23	+ ·06	− ·02	13·87	17 04 51·94	−21·93	+ ·07
	δ Herculis......	11 27·55	+ ·11	− ·37	− ·24	+ ·05	− ·02	27·08	11 05·23	·85	− ·01
	β Aræ..........	17 40·55	+ ·19	+ ·52	− ·39	+ ·04	− ·04	40·87	17 18·98	·89	+ ·03
	σ Ophiuchi.. ..	22 07·02	+ ·12	− ·19	·22	+ ·04	− ·02	06·75	21 44·87	·88	+ ·02
	λ Scorpii......	27 26·89	+ ·16	+ ·20	− ·28	+ ·03	− ·03	26·97	27 05·09	·88	·02
	α Ophiuchi.	30 50·82	+ ·11	− ·25	− ·23	+ ·02	− ·02	50·45	30 28·60	85	− ·01
	η Pavonis . .	36 40·09	+ ·13	+ ·83	− ·52	+ ·01	− ·05	40·49	36 18·69	80	06
W	89 Herculis.....	51 55·03	− ·04	− ·38	+ ·25	− ·01	− ·02	54·83	51 33·04	·79	− ·07
	ν Ophiuchi.	54 06·18	− ·05	− ·07	+ ·22	− ·02	− ·02	06·24	53 44·35	·89	+ ·03
	γ² Sagittarii	59 59·96	− ·06	+ ·12	+ ·26	− ·03	− ·02	60·23	59 38·27	·96	+ ·10
	72 Ophiuchi.....	18 03 09·99	− ·04	− ·23	+ ·22	− ·03	− ·02	09·80	18 02 47·93	·87	+ ·01
	μ Sagittarii.....	08 23·00	− ·05	+ ·02	+ ·23	− ·04	− ·03	23·13	08 01·21	·92	+ ·06
	η Serpentis.	16 42·33	− ·04	− ·13	+ ·22	− ·05	− ·03	42·30	16 20·53	·77	09
	α Telescopii	20 12·60	− ·06	+ ·33	+ ·32	− ·06	− ·02	13·11	19 51·30	·81	·05

$a = +^{s}\cdot489 \qquad c = -^{s}\cdot222$

Chronometer correction at $17^{h}\ 43^{m} = -21^{s}\cdot863 \pm {}^{s}\cdot011$

TRANSIT OBSERVATIONS.

Station : SUVA. Date, August 14th, 1903. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R.A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·08	s.		h. m. s.	s.	s.
E	ε Herculis....	16 57 03·70	− ·09	− ·49	− ·21	+ ·07	− ·02	02·96	16 56 36·85	−26·11	− ·06
	δ Herculis.....	17 11 32·00	− ·09	·42	·20	− ·06	− ·02	31·33	17 11 05·18	·15	− ·02
	β Aræ	17 44·96	− ·16	+ ·59	− ·31	+ ·05	− ·04	45·09	17 18·91	·18	+ ·01
W	ξ Serpentis...	18 16 46·95	− ·15	·15	+ ·18	·03	− ·02	46·78	18 16 20·50	·28	+ ·11
	α Telescopii	20 17·07	− ·20	·38	+ ·26	·04	·03	17·44	19 51·26	·18	− ·01
	λ Sagittarii ...	22 28·87	− ·17	·08	·20	·04	− ·02	28·92	22 02·65	·27	− ·10
	α Lyræ	34 08·70	− ·11	·60	+ ·23	·05	− ·03	08·14	33 42·01	·13	·04
	β Aquilæ......	37 27·33	− ·16	·09	·18	·06	− ·02	27·24	37 01·08	·16	− ·01
	λ Pavonis ...	43 44·96	− ·25	·84	+ ·38	·07	− ·04	45·82	43 19·72	·10	− ·07
	σ Sagittarii	49 44·95	− ·18	+ ·09	+ ·20	·07	− ·02	44·97	49 18·72	·25	+ ·08

a = −s·560 c = −s·178

Chronometer correction at $17^{h}\ 53^{m} = -26^{s}\cdot173 \pm {}^{s}\cdot017$.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R.A.	Chronometer correction.	v.
W	γ Aquilæ.....	19 42 08·67	+ ·04	− ·28	− ·16	+ ·08	− ·02	08·65	19 41 42·14	−26·51	+ ·07
	α Aquilæ	46 32·77	+ ·03	− ·34	+ ·16	+ ·07	− ·02	32·67	46 06·34	·33	·11
	ι Sagittarii.....	49 04·35	+ ·05	+ ·30	+ ·22	+ ·07	− ·03	04·96	48 38·45	·51	− ·07
	α Pavonis ..	20 18 29·08	+ ·06	+ ·65	+ ·30	+ ·03	− ·04	30·08	20 18 03·69	·39	− ·05
	ρ Capricorni ...	23 49·66	+ ·04	·00	− ·17	+ ·02	− ·02	49·87	23 23·33	·54	+ ·10
	ε Delphini	29 04·57	+ ·04	− ·28	− ·16	+ ·01	− ·02	04·48	28 38·09	·39	− ·05
	α Delphini	35 37·89	+ ·03	− ·32	+ ·17	− ·01	− ·02	37·76	35 11·33	·43	− ·01
E	ε Aquarii	42 55·53	+ ·31	− ·08	− ·16	·06	− ·02	55·58	42 29·03	·55	+ ·11
	μ Aquarii	47 55·26	+ ·31	− ·08	− ·16	·01	− ·02	55·30	47 28·85	·45	− ·01
	ι Piscis Aust...	55 50·52	+ ·36	·17	·19	− ·02	− ·02	50·82	55 24·46	·36	·08
	α Equulei	21 11 28·57	+ ·29	− ·22	− ·16	·04	− ·02	28·42	21 11 01·95	·47	− ·03
	ζ Capricorni....	21 37·75	+ ·34	+ ·05	− ·18	− ·05	− ·02	37·89	21 11·45	·44	·00
	ε Pegasi.......	39 55·37	+ ·28	− ·27	·16	·08	− ·02	55·12	39 28·75	·37	·07

a = −s·564 c = −s·161

Chronometer correction at $20^{h}\ 40^{m} = -26^{s}\cdot441 \pm {}^{s}\cdot015$.

TRANSIT OBSERVATIONS.

Station: Suva. Date, August 17th, 1903. Observer: Otto Klotz.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R.A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = −·08	s.		h. m. s.	s.	s.
E	η Serpentis......	18 16 52·06	+·06	·13	·18	·07	·02	51·86	18 16 20·47	−31·39	+·09
	α Lyræ.........	34 13·97	+·04	−·54	−·21	+·04	·03	13·27	33 41·97	·30	00
	2 Aquilæ.. . .	37 32·47	+·06	·08	·18	+·04	·02	32·29	37 01·06	·23	·07
	λ Pavonis	43 50·44	+·08	−·76	·38	+·03	·04	50·89	43 19·65	·24	06
	σ Sagittarii.....	49 50·13	+·06	·08	·20	+·02	·02	50·07	49 18·70	·37	+·07
W	π Sagittarii.....	19 04 34·59	·16	+·03	·19	·00	02	34·63	19 04 03·32	·31	+·01
	α Aquilæ......	46 37·88	·12	−·31	·18	·05	·02	37·56	46 06·33	·23	·07
	ι Sagittarii. .	49 09·45	·18	+·27	·24	−·06	·03	09·69	48 38·41	·28	·02
	β Aquilæ.	51 07·76	·14	−·21	+·18	−·06	02	07·51	50 36·20	·31	+·01
	ε Sagittarii. ...	57 16·77	·17	+·10	·20	−·07	02	16·81	56 45·49	·32	+·02

a = +s·509 c = −s·175

Chronometer correction at $19^h\ 06^m = -31^s{\cdot}299 \pm {}^s{\cdot}013$.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R.A.	Chronometer correction.	v.
W	θ Aquilæ.	20 06 52·97	·14	−·15	+·23	+·09	−·02	52·98	20 06 21·41	−31·57	+·11
	α¹ Capricorni....	12 51·19	·15	−·05	+·23	+·08	−·02	51·28	12 19·86	·42	−·04
	α² Capricorni....	13 15·37	·15	·05	+·23	+·08	−·02	15·46	12 43·92	·54	+·08
	α Pavonis	18 34·19	·22	+·60	+·41	+·08	−·04	35·02	18 03·69	·33	−·13
	ρ Capricorni ...	23 54·79	−·16	·00	+·24	+·07	−·02	54·92	23 23·34	·58	+·12
	α Indi.....	31 20·06	·20	+·38	+·33	·06	−·03	20·60	30 49·14	·46	·00
E	β Aquarii......	21 27 02·36	+·06	−·11	−·23	·02	−·02	02·04	21 26 30·68	·36	·10
	γ Gruis	48 38·71	+·08	+·22	·29	·04	−·03	38·65	48 07·19	·46	00
	α Aquarii..	22 01 23·37	+·06	−·16	·23	·06	−·02	22·96	22 00 51·56	·40	·06
	ι Pegasi	03 05·41	+·05	−·39	−·25	·07	−·02	04·73	02 33·29	·44	−·02
	α Toucani	12 27·38	+·10	+·73	·46	−·08	−·04	27·63	11 56·08	·55	+·09
	γ Aquarii.....	17 14·00	+·06	−·15	−·23	−·08	−·02	13·58	16 42·19	·39	·07
	σ Aquarii.... .	26 06·06	+·07	·06	−·23	−·09	−·02	05·73	25 34·27	·46	·00

$a = +{}^s{\cdot}524 \qquad c = -{}^s{\cdot}225$

Chronometer correction at $21^h\ 15^m = -31^s{\cdot}461 \pm {}^s{\cdot}017$.

TRANSIT OBSERVATIONS.

Station: SUVA. Date, August 19th, 1903. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·09	s.		h. m. s.	s.	s.
E	72 Ophiuchi.....	18 03 22·47	+ ·02	− ·22	− ·18	+ ·12	− ·02	22·19	18 02 47·87	−34·32	·00
	η Serpentis. ...	16 55·09	+ ·03	− ·12	− ·18	+ ·10	− ·02	54·90	16 20·45	·45	− ·13
	α Telescopii....	20 25·32	+ ·03	+ ·32	− ·26	+ ·09	− ·03	25·47	19 51·19	·28	·04
	λ Sagittarii	22 36·93	+ ·03	+ ·07	− ·20	+ ·09	− ·02	36·90	22 02·60	·30	− ·02
	α Lyræ....	34 16·88	+ ·02	− ·51	− ·23	·07	− ·03	16·20	33 41·94	·26	− ·06
	σ Sagittarii	49 53·05	+ ·03	+ ·08	− ·20	+ ·05	− ·02	52·99	49 18·68	·31	− ·01
W	ι Sagittarii	19 49 12·55	− ·17	+ ·26	+ ·24	·04	− ·03	12·81	19 48 38·43	·38	+ ·06
	c Sagittarii	57 19·85	− ·16	+ ·09	+ ·20	·05	− ·02	19·91	56 45·49	·42	+ ·10
	ε Delphini.. ..	20 29 12·70	− ·13	− ·23	+ ·18	·10	− ·02	12·40	20 28 38·09	·31	− ·01
	α Indi..........	31 23·01	− ·18	+ ·35	+ ·26	·10	− ·03	23·31	30 49·14	·17	− ·15
	α Delphini. ...	35 45·94	− ·12	− ·27	+ ·19	·11	− ·02	45·61	35 11·33	·28	− ·04
	ε Aquarii.. ..	43 03·55	− ·14	− ·07	+ ·18	·12	− ·02	03·38	42 29·04	·34	+ ·02

$a = +^{s}\cdot476$ $c = -^{s}\cdot179$

Chronometer correction at $19^h\ 23^m = -34^s\cdot317 \pm {}^s\cdot017$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	θ Capricorni....	21 01 07·86	− ·13	− ·01	+ ·21	+ ·09	− ·02	08·00	21 00 33·34	−34·66	+ ·11
	ζ Cygni.... ...	09 26·76	·09	− ·43	+ ·23	− ·08	− ·02	26·53	08 51·99	·54	− ·01
	β Aquarii..	27 05·18	− ·12	·11	+ ·20	+ ·05	− ·02	05·18	26 30·69	·49	− ·06
	ξ Aquarii.. ...	33 13·31	·12	− ·09	+ ·20	+ ·04	− ·02	13·32	32 38·84	·48	− ·07
	γ Capricorni....	35 21·11	·13	·61	+ ·21	+ ·04	− ·02	21·29	34 46·63	·57	− ·02
	ε Pegasi..	40 03·43	− ·11	− ·24	+ ·20	+ ·03	− ·02	03·29	39 28·78	·51	− ·04
	δ Capricorni....	42 19·34	− ·13	− ·02	+ ·21	+ ·03	− ·02	19·41	41 44·83	·58	+ ·03
E	σ Aquarii	22 26 08·98	+ ·21	− ·06	− ·21	− ·04	− ·02	08·86	22 25 34·29	·57	− ·02
	β Gruis	37 30·69	− ·27	+ ·37	·30	− ·06	− ·03	30·94	36 56·42	·52	− ·03
	η Pegasi.	39 06·08	+ ·16	·43	− ·23	− ·06	− ·02	05·50	38 30·97	·53	− ·02
	λ Aquarii ...	48 11·33	+ ·20	− ·09	− ·20	− ·07	− ·02	11·15	47 36·63	·52	− ·03
	δ Aquarii	50 08·22	− ·21	− ·02	− ·21	− ·07	− ·02	08·11	49 33·54	·57	+ ·02
	α Piscis Aust...	52 55·47	− ·23	− ·12	− ·24	− ·08	− ·02	55·48	52 20·95	·53	− ·02
	α Pegasi.... ...	23 00 34·20	− ·18	− ·29	− ·21	− ·09	− ·02	33·77	59 59·19	·58	+ ·03

$a = +^{s}\cdot505$ $c = -^{s}\cdot203$

Chronometer correction at $22^h\ 00^m = -34^s\cdot551 \pm {}^s\cdot009$

TRANSIT OBSERVATIONS.

Station : Suva. Date, August 21st, 1903. Observer : Otto Klotz.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	r.
		h. m. s.	s.	s.	s.	s. r = − ·11	s.		h. m. s.	s.	s.
E	γ^2 Sagittarii....	18 00 15·49	+ ·28	+ ·15	− ·26	+ ·07	·02	15 71	17 59 38·15	37·56	+ ·09
	72 Ophiuchi.....	03 25·51	+ ·22	− ·28	− ·22	+ ·07	·02	25 28	18 02 47·84	·44	·03
	μ Sagittarii....	08 38·47	+ ·27	− ·02	·24	+ ·06	·02	38·56	08 01·11	·45	− ·02
	η Serpentis....	16 57·98	+ ·24	·16	·22	+ ·04	·02	57·86	16 20 43	·43	·04
	α Telescopii...	20 28·19	+ ·32	− ·40	− ·32	+ ·04	·03	28·60	19 51·15	·45	·02
	λ Sagittarii...	22 39·89	+ ·28	− ·08	·24	+ ·03	·02	40 02	22 02·57	·45	− ·02
W	α Lyræ.....	34 19·76	+ ·01	− ·64	− ·28	+ ·01	·03	19·39	33 41·90	49	+ ·02
	2 Aquilæ...	37 38 34	+ ·01	·10	− ·22	+ ·01	·02	38·46	37 01·02	·44	·03
	λ Pavonis.....	43 55·68	+ ·02	+ 92	− ·47	− ·01	·04	57·04	43 19·57	·47	·00
	σ Sagittarii....	49 55·88	+ ·01	− ·10	− ·25	·02	·02	56·20	49 18·66	·54	+ ·07
	ϵ Aquilæ.....	55 53·73	+ ·01	− ·34	− 23	·03	·02	53·58	55 16·17	·41	06
	ζ Aquilæ...	19 01 37·69	+ ·01	·14	− ·22	− ·04	·02	37·72	19 01 00·11	61	+ ·14
	π Sagittarii....	04 40·44	+ ·01	+ ·03	− ·24	− ·04	·02	40·66	04 03·28	·38	− ·09
	δ Aquilæ......	21 17·23	+ ·01	·22	− ·22	·07	·02	17 15	20 39·69	46	− ·01

$a = -$ ·601 $c = -$ ·220

Chronometer correction at $18^h\ 40^m = -37^s{\cdot}470 \pm {}^s{\cdot}013$.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	r.
W	β Aquilæ......	19 51 13·64	+ ·09	·21	− ·25	+ ·07	− ·02	13 82	19 50 36 18	−37·64	+ ·01
	c Sagittarii	57 22·56	+ ·11	+ ·10	+ ·28	+ ·06	− ·02	23·09	56 45·48	·61	·02
	θ Aquilæ......	20 06 58·88	+ ·10	15	+ ·25	+ ·04	− ·02	59·10	20 06 21·40	·70	+ ·07
	α^1 Capricorni....	12 57·22	+ ·10	− ·05	+ ·25	+ ·03	− ·02	57·53	12 19·85	·68	+ ·05
	α^2 Capricorni...	13 21·29	+ ·10	·05	+ ·25	+ ·03	− ·02	21·60	12 43·92	·68	+ ·05
	α Pavonis......	18 40·03	+ ·14	+ ·59	+ ·46	·02	− ·04	41·20	18 03·67	·53	·10
	ρ Capricorni....	24 00·67	+ ·11	·00	+ ·26	+ ·01	− ·02	01·03	23 23·33	·70	+ ·07
E	ϵ Delphini.....	29 15·97	+ 35	− ·25	·25	·00	− ·02	15·80	28 38·08	·72	+ ·09
	α Indi.........	31 26·38	+ ·51	+ ·37	− ·40	·00	− ·03	26·83	30 49·13	·70	+ ·07
	α Delphini.....	35 49·13	+ ·34	− ·29	− ·26	− ·01	− ·02	48·89	35 11 33	·56	·07
	ϵ Aquarii	43 06·72	+ ·37	·08	·25	·02	− ·02	06·72	42 29·04	·68	+ ·05
	ι Piscis Aust....	56 01·85	+ ·45	+ ·15	− ·30	− ·05	− ·02	02·08	55 24·48	·60	− ·03
	θ Capricorni ...	21 01 10·81	+ ·41	− ·01	− ·26	− ·06	− ·02	10·87	21 00 33 34	·53	− ·10
	ζ Cygni	09 29·99	+ ·30	− ·44	− ·29	− ·07	− ·02	29·47	08 51 99	·48	·15

$a = +$ ·513 $c = -$ ·252

Chronometer correction at $20^h\ 30^m = -37^s{\cdot}630 \pm {}^s{\cdot}015$

TRANSIT OBSERVATIONS.

Station : Suva. Date, August 22nd, 1903. Observer : Otto Klotz.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r – - 11	s.		h. m. s.	s.	s.
E	β Aræ	17 17 57·21	+ ·07	+ ·51	– ·38	+ ·28	– ·04	57·65	17 17 18·71	– 38·94	+ ·05
	[illegible] Ophiuchi . .	22 23·68	+ ·05	– ·19	– ·22	+ ·27	– ·02	23·57	21 44·72	·85	– ·04
	λ Scorpii	27 43·90	+ ·07	+ ·19	·28	+ ·26	– ·03	43·81	27 04·91	·90	– ·01
	α Ophiuchi	31 07·52	+ ·05	– ·25	– ·22	+ ·25	– ·02	07·33	30 28 44	·89	·00
	η Pavonis. . .	36 56·59	+ ·09	+ ·82	– ·51	+ ·24	– ·05	57·18	36 18 33	·85	· 04
	β Ophiuchi	39 22·58	+ ·05	– ·19	– ·22	+ ·24	– ·02	22·44	38 43 54	·90	+ ·01
W	γ Capricorni .	21 35 25·56	·00	– ·01	+ ·23	·19	– ·02	25·57	21 34 46 64	93	+ ·04
	ε Pegasi. . . .	40 07·83	00	·25	+ ·22	·20	– ·02	07·60	39 28·79	·81	·08
	δ Capricorni . . .	42 23·82	00	– ·01	+ ·23	·21	– ·02	23·81	41 44 84	·97	+ ·08
	γ Gruis . . .	48 45·98	09	+ ·20	+ ·28	·22	– ·03	46·21	48 07 23	·98	+ ·09
	α Gruis . . .	22 02 49·75	00	+ ·35	+ ·32	·24	– ·03	50·15	22 02 11·36	·79	– 10
	γ Aquarii . .	17 21·35	·00	– ·14	+ ·22	·27	– ·02	21·14	16 42·23	·91	+ ·02

a = ·485 c = ·217

Chronometer correction at $19^h\ 49^m = -38^s{\cdot}894 \pm {}^s{\cdot}012$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	[illegible] Aquarii. .	22 31 04·96	·02	– 16	·21	·08	– ·03	05 04	22 30 25 77	– 39·27	·00
	β Gruis.	37 35·02	02	+ ·39	+ ·31	+ ·07	– ·03	35·74	36 56 46	·28	+ ·01
	α Pegasi. .	23 00 38·60	·01	– ·30	·21	+ 03	– ·02	38·51	59 59·23	·28	+ 01
	γ Piscium	12 50·81	– 02	– 19	– ·21	+ ·01	– ·02	50·80	23 12 11 62	18	·09
	[illegible] Pegasi. .	16 33·17	02	– 33	+ ·23	·00	– ·02	33·03	15 53 72	31	+ 04
E	[illegible] Piscium	22 40 36	·28	– ·17	– ·21	– ·01	– ·02	40·23	22 00·96	·27	·00
	ι Piscium	35 40·48	·28	·21	·21	·04	– ·02	40·28	35 01·00	·28	+ 01
	δ Sculptoris. . . .	44 34·79	+ 34	+ ·11	– ·24	05	– ·02	34·93	43 55·65	·28	– 01
	φ Pegasi.	48 16·29	+ ·25	– ·34	– ·22	– ·06	– ·02	15 90	47 36 65	·25	– ·02
	ω Piscium	55 02·63	·28	·22	·21	·07	– ·02	02·39	54 23·12	·27	00
	2 Ceti.	59 28·67	+ ·32	– ·01	·22	·08	– ·02	28·66	58 49·40	·26	·01

a = – ·536 c = – ·210

Chronometer correction at $23^h\ 15^m = -39^s{\cdot}266 - {}^s{\cdot}009$

TRANSIT OBSERVATIONS.

Station ; Suva. Date, August 23rd, 1903. Observer : Otto Klotz.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	r.
		h. m. s.	s.	s.	s.	r = s. ·10	s.		h. m. s.	s.	s.
E	θ Capricorni....	21 01 13·85	·17	01	·24	·06	·02	13·81	21 00 33·34	40·47	+ ·01
	ζ Cygni........	09 32·98	·12	46	·26	05	·02	32·41	08 51·98	·43	− ·03
	α Equulei	11 42·71	·15	·21	·23	05	·02	42·45	11 01·98	47	+ ·01
	θ¹ Microscopii..	15 17·84	18	·29	·30	·04	03	18·02	14 37·47	·55	+ ·09
	ζ Capricorni ..	21 51·96	·17	·05	·25	03	02	51·94	21 11·49	45	− ·01
	β Aquarii .. .	27 11·30	·16	12	·23	02	02	11·11	26 30·70	41	− ·05
	γ Capricorni....	35 27·15	·17	01	23	·01	02	27·07	34 46·65	·42	− ·04
W	ι Pegasi. . .	40 09·45	·12	26	·23	·00	·02	09·28	39 28·79	·49	+ ·03
	δ Capricorni....	42 25·27	14	02	24	·01	02	25·32	41 44·84	·48	+ ·02
	γ Gruis.	48 47·39	·16	23	29	02	03	47·70	48 07·25	·45	− ·01
	20 Pegasi... ..	57 05·98	12	·29	24	·03	02	05·76	56 25·30	·46	00
	α Aquarii .. .	22 01 32·14	·13	·16	·23	04	02	32·02	22 00 51·60	·42	− ·04
	α Toucani .. .	12 35·66	20	+ ·76	47	05	04	36·60	11 56·17	·43	− ·03
	γ Aquarii	17 22·94	·14	·15	·25	·06	02	22·80	16 42·24	·56	+ ·10

$a = +^{s}{\cdot}543$ $c = -^{s}{\cdot}227$

Chronometer correction at $21^{h}\ 39^{m} = -40^{s}{\cdot}461 \pm {}^{s}{\cdot}010$

TRANSIT OBSERVATIONS.

Station : Suva. Date, August 25th, 1903. Observer : Otto Klotz.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	r.
		h. m. s.	s.	s.	s.	r = s. ·10	s.		h. m. s.	s.	s.
E	α Toucani.......	22 12 37·26	·45	− ·60	− ·50	·12	·04	37·89	22 11 56·19	−41·70	·03
	η Aquarii	31 07·54	·29	− ·13	− ·24	·09	02	07·53	30 25·79	74	·07
	ζ Pegasi	37 22·77	·27	·21	− ·25	·08	·02	22·64	36 40·96	·68	+ ·01
	η Pegasi	39 13·00	·23	− ·37	− ·28	·08	02	12·64	38 31·02	·62	·05
	ε Gruis	43 26·92	·40	+ ·38	·39	·07	·03	27·35	42 45·72	·63	·04
	λ Aquarii.	48 18·37	·30	·07	− ·24	+ ·06	− ·02	18·40	47 36·70	70	+ ·03
	δ Aquarii.	50 15·17	·31	− ·01	− ·25	·06	02	15·26	49 33·60	·66	·01
W	ω Piscium ...	23 55 04·89	01	18	+ ·24	·05	02	04·87	23 54 23·17	·70	·03
	2 Ceti	59 30·93	01	·00	+ ·25	− ·06	02	31·09	58 49·45	·64	− ·03
	α Andromedæ..	24 04 08·03	·00	·36	+ ·27	·06	− ·02	07·86	24 03 26·07	·79	+ ·12
	γ Pegasi.......	08 59·61	·01	− ·24	+ ·25	− ·07	·02	59·52	08 17·86	·66	·01
	α Phœnicis......	22 13·57	01	+ ·24	+ ·33	·09	·03	14·01	21 32·48	·53	·14
	δ Andromedæ..	34 53·98	01	·33	+ ·28	− ·11	− 02	53·79	34 12·10	·69	+ ·02
	β Ceti....... .	39 27·81	·01	·00	+ ·2	− ·12	− ·02	27·90	38 46·24	·66	− ·01

$a = +^{s}{\cdot}431$ $c = -^{s}{\cdot}243$

Chronometer correction at $23^{h}\ 25^{m} = -41^{s}{\cdot}674 - {}^{s}{\cdot}010$

TRANSIT OBSERVATIONS.

Station: SUVA. Date, August 27th, 1903. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·06	s.		h. m. s.	s.	s.
E	μ Herculis.....	17 43 25·39	+ ·08	− ·47	− ·27	− ·03	− ·02	24·74	17 42 41·98	−42·76	·06
	89 Herculis.....	52 16·19	+ ·08	− ·45	− ·27	− ·02	− ·02	15·55	51 32·79	·76	·06
	ν Ophiuchi......	54 27·22	+ ·10	− ·09	·24	+ ·02	− ·02	26·99	53 44·15	·84	+ ·02
	γ² Sagittarii....	18 00 20·99	+ ·11	+ ·15	− ·28	+ ·01	− ·02	20·96	59 38·05	·91	+ ·09
	72 Ophiuchi......	03 31·02	+ ·09	− ·28	− ·24	− ·01	− ·02	30·58	18 02 47·75	·83	+ ·01
	μ Sagittarii....	08 44·00	+ ·10	+ ·02	− ·26	·01	− ·02	43·85	08 01·03	·82	·00
W	η Serpentis.....	17 03·33	− ·22	− ·15	+ ·24	·00	− ·02	03·18	16 20·35	·83	+ ·01
	α Telescopii....	20 33·42	− ·29	+ ·39	+ ·35	·01	− ·03	33·83	19 51·05	·78	− ·04
	λ Sagittarii....	22 45·31	− ·25	+ ·08	+ ·27	− ·01	− ·02	45·38	22 02·49	·89	+ ·07
	α Lyræ......	34 25·19	− ·16	− ·63	+ ·31	− ·02	− ·03	24·66	33 41·79	·87	+ ·05
	2 Aquilæ.....	37 43·86	− ·23	− ·09	+ ·24	− ·02	− ·02	43·74	37 00·95	·79	− ·03
	λ Pavonis......	44 01·22	− ·36	+ ·88	+ ·52	·03	− ·04	02·19	43 19·41	·78	− ·04

$a = -{}^{s}{\cdot}586$ $c = -{}^{s}{\cdot}242$

Chronometer correction at $18^{h}\ 13^{m} = -42^{s}{\cdot}821 \pm {}^{s}{\cdot}011$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	ε Aquilæ......	18 55 59·22	− ·18	·32	+ ·28	+ ·04	− ·02	59·02	18 55 16·09	−42·93	+ ·03
	ζ Aquilæ......	19 01 43·20	− ·18	− ·31	+ ·28	− ·04	− ·02	43·01	19 01 00·05	·96	+ ·06
	ψ Sagittarii....	10 22·01	·23	+ ·08	+ ·30	+ ·03	− ·02	22·17	09 39·21	·96	+ ·06
	ω Aquilæ.....	14 01·93	·19	− ·28	+ ·27	+ ·03	− ·02	01·74	13 18·84	·90	·00
	B.A.C. 6632....	20 47·84	− ·29	·58	− ·46	+ ·02	− ·04	48·57	20 05·72	·85	·05
	α Vulpeculæ....	25 26·31	·16	− ·42	+ ·29	+ ·01	− ·02	26·01	24 43·11	·90	·00
	μ Aquilæ......	30 07·26	− ·19	− ·25	+ ·27	+ ·01	− ·02	07·08	29 24·22	·86	− ·04
E	c¹ Sagittarii.....	35 56·55	+ ·19	·02	− ·28	·00	− ·02	56·42	35 13·47	·95	− ·05
	γ Aquilæ.....	42 25·35	+ ·17	− ·28	·27	·00	− ·02	24·95	41 42·06	·89	− ·01
	α Aquilæ....	46 19·53	+ ·15	·34	− ·27	− ·01	− ·02	49·04	46 06·26	·78	·12
	ι Sagittarii.....	49 21·16	+ ·23	+ ·31	·36	− ·01	− ·03	21·30	48 38·36	·94	+ ·04
	β Aquilæ.....	51 19·40	− ·16	·23	− ·27	− ·01	− ·02	19·03	50 36·15	·88	− ·02
	c Sagittarii.....	57 28·37	+ ·26	+ ·11	− ·30	− ·02	− ·02	28·34	56 45·45	·89	·01
	ρ Capricorni....	20 24 06·36	− ·19	·00	− ·28	·04	− ·02	06·21	20 23 23·31	·90	·00

$a = -{}^{s}{\cdot}565$ $c = -{}^{s}{\cdot}267$

Chronometer correction at $19^{h}\ 40^{m} = -42^{s}{\cdot}899 \pm {}^{s}{\cdot}010$

TRANSIT OBSERVATIONS.

Station: NORFOLK ISLAND. Date, August 14th, 1903. Observer: F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·29	s.		h. m. s.	m. s.	s.
E	λ Scorpii......	17 28 04·15	+ ·06	+ ·09	+ ·08	+ ·06	− ·02	04·42	17 27 05·04	−59 ·38	+ ·03
	241.	31 28·00	+ ·04	·35	+ ·07	+ ·04	− ·02	27·78	30 28·52	·26	·09
	600.	33 04·37	+ ·05	− ·12	+ ·07	+ ·04	− ·02	04·39	32 05·04	·35	·00
	η Pavonis......	37 16·96	+ ·10	+ ·70	+ ·16	+ ·02	− ·04	17·90	36 18·60	·30	·05
	245.	39 43·20	·04	·28	+ ·07	·00	− ·02	43·01	38 43·61	·40	+ ·05
	246............	43 41·99	+ ·03	− ·49	+ ·05	− ·02	− ·02	41·57	42 42·17	·40	+ ·05
W	250............	54 43·83	+ ·02	− ·17	− ·08	·07	− ·02	43·52	53 44·27	·25	·10
	253..........	56 49·81	+ ·02	·27	− ·07	·07	− ·02	49·40	55 50·09	·31	·04
	601..........	18 00 37·85	+ ·02	+ ·02	− ·08	− ·09	− ·02	37·70	59 38·22	·48	+ ·13
	254..........	03 47·74	·02	·33	− ·07	·11	·02	47·23	18 02 47·88	·35	·00

$a = +^s{\cdot}518 \qquad c = +^s{\cdot}067$

Chronometer correction at $17^h\ 40^m = -59^s{\cdot}348 \pm ^s{\cdot}019$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	603............	18 50 18·47	+ ·04	·03	− ·05	+ ·29	− ·02	18·70	18 49 18·69	−1 00·01	+ ·03
	270............	19 02 00·35	+ ·03	·39	·05	+ ·23	− ·02	00·15	19 01 00·14	00·01	+ ·03
	604.. ..	05 03·28	+ ·04	·08	− ·05	+ ·22	− ·02	03·39	04 03·30	00·09	+ ·11
	ψ Sagittarii.....	10 39·16	+ ·04	− ·04	− ·05	+ ·19	− ·02	39·28	09 39·32	0 59·96	·02
	ι^1 Sagittarii......	36 13·53	+ ·04	− ·12	− ·05	+ ·07	− ·02	13·45	35 13·55	59·90	·08
	ι Sagittarii.....	49 38·21	+ ·05	+ ·17	− ·06	+ ·05	− ·02	38·40	48 38·45	59·95	− ·03
	283..........	51 36·45	+ ·03	·32	− ·05	− ·01	− ·02	36·08	50 36·18	59·90	− ·08
E	607.	20 13 44·13	+ ·08	− ·25	+ ·05	− ·11	− ·02	43·88	20 12 43·91	59·97	·01
	608.	16 37·41	+ ·09	·22	+ ·05	− ·13	− ·02	37·18	15 37·32	59·86	− ·12
	α Pavonis......	19 02·84	+ ·14	+ ·75	+ ·08	− ·14	− ·03	03·64	18 03·69	59·95	− ·03
	609......	24 23·61	+ ·09	− ·18	+ ·05	− ·16	− ·02	23·39	23 23·33	1 00·06	+ ·08
	290..........	29 38·66	+ ·07	− ·58	+ ·05	− ·19	− ·02	37·99	28 38·06	0 59·93	− ·05
	297..	43 29·45	+ ·07	− ·29	+ ·05	− ·25	− ·02	29·01	42 28·93	1 00·08	+ ·10
	μ Aquarii.......	48 29·32	+ ·07	− ·30	+ ·05	− ·28	− ·02	28·84	47 28·85	0 59·99	+ ·01

$a_1 = +^s{\cdot}557 \qquad a_2 = +^s{\cdot}875 \qquad c = -^s{\cdot}045$

Chronometer correction at $19^h\ 50^m = -59^s{\cdot}976 \pm ^s.016$

TRANSIT OBSERVATIONS.

Station: NORFOLK ISLAND. Date, August 17th, 1903. Observer: F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·18	s.		h. m. s.	m. s.	s.
W	σ Ophiuchi	17 23 07·82	− ·01	+ ·40	− ·12	+ ·08	− ·02	08·15	17 21 44·78	−1 23·37	·00
	η Pavonis	37 43 12	− ·03	−1 ·00	− ·29	+ 04	− ·04	41·80	36 18·47	·33	− ·04
	245	40 06 66	− ·01	+ ·40	− ·12	+ ·03	− ·02	06 94	38 43·57	·37	·00
	246	44 05 07	− ·01	+ ·69	− ·14	+ ·02	− ·02	05·61	42 42 13	·48	+ ·11
	250	55 07 47	− ·01	+ ·24	− ·12	·01	− ·02	07 55	53 44·24	·31	·06
	253	57 13·21	− ·01	+ ·39	− ·12	− ·02	− ·02	13·43	55 50 06	37	·00
E	601	18 01 01 47	+ ·07	− ·02	+ ·14	·03	− ·02	01·61	59 38·19	·42	+ ·05
	254	04 10 57	+ ·05	+ ·46	+ ·12	·04	− ·02	11·14	18 02 47.86	·28	− ·09
	255	05 10 60	+ ·03	+ ·70	+ ·14	− ·04	− ·02	11·41	03 48·08	·33	·04
	ε Sagittarii	19 11.25	+ ·05	− ·09	+ ·15	− ·09	− ·02	11·25	17 47·84	·41	+ ·04

$a = -{}^{s}\cdot733 \qquad c = +{}^{s}\cdot122$

Chronometer correction at $17^{h}\ 50^{m} = -1^{m}23^{s}\cdot368 \pm {}^{s}\cdot016$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
E	λ Pavonis	18 44 43·46	+ ·07	·59	+ ·34	+ ·09	− ·04	43·33	18 43 19.64	−1 23·69	+ ·09
	603	50 41·90	+ ·04	+ ·03	+ ·17	+ ·07	− ·02	42·19	49 18·67	·52	− ·08
	267	56 39·13	+ ·03	+ ·36	+ ·16	+ ·06	− ·02	39·72	55 16·19	·53	·07
	270	19 02 23 22	+ ·03	+ ·35	+ ·16	+ ·04	− ·02	23 78	19 00 60 13	·65	− ·05
	604	05 26·70	+ ·03	+ ·08	+ ·17	+ ·03	− ·02	26·99	03 63·27	·72	+ ·12
	ϑ Sagittarii	11 02·54	− ·03	+ ·04	+ ·17	+ ·01	− ·02	02·77	09 39·30	·47	− ·13
	495	14 41·98	·03	+ ·33	+ ·16	·00	− ·02	42·48	13 18·89	·59	− ·01
W	B. A. C. 6632	21 30 12	− ·02	·37	− ·27	·02	− ·03	29 41	20 05·85	·56	− ·04
	α Vulpeculæ	26 06·61	− ·01	+ ·44	− ·17	− ·03	− ·02	06·82	24 43·24	·58	− ·02
	605	32 15·74	− ·02	+ ·04	− ·17	− ·05	− ·02	15 52	30 51·99	·53	− ·07
	ρ¹ Sagittarii	36 37·32	− ·02	+ ·11	− ·16	− ·06	− ·02	37·17	35 13·52	·65	+ ·05
	277	43 05·67	02	+ ·33	− ·16	− ·08	− ·02	05·72	41 42·09	.63	+ ·03
	279	44 30·54	− ·02	+ ·39	− ·16	− ·09	− ·02	30 64	43 06·92	·72	+ ·12

$a = -{}^{s}\cdot501 \qquad c = +{}^{s}\cdot156$

Chronometer correction at $19^{h}\ 15^{m} = -1^{m}23^{s}\cdot601 \pm {}^{s}\cdot018$

TRANSIT OBSERVATIONS.

Station : NORFOLK ISLAND. Date, August 19th, 1903. Observer : F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	c.
		h. m. s.	s.	s.	s.	s. r = − ·34	s.		h. m. s.	m. s.	s.
E	β Aræ	17 18 57·58	− ·02	+ ·35	+ ·16	+ ·17	− ·03	58·21	17 17 18·79	1 39·42	− ·07
	σ Ophiuchi	23 24·21	·00	− ·25	+ ·09	+ ·15	− ·02	24·18	21 44·77	·41	− ·08
	λ Scorpii	28 44·09	·00	− ·08	+ ·11	+ ·12	− ·02	44·38	27 04·97	·41	·08
	η Pavonis	37 57·14	+ ·02	+ ·61	+ ·21	+ ·07	− ·04	58·01	36 18·44	·57	+ ·08
	245	40 23·25	+ ·01	− ·25	+ ·09	+ ·06	− ·02	23·14	38 43·55	·59	− ·10
	246	44 21·98	+ ·01	·42	+ ·10	+ ·03	− ·02	21·68	42 42·10	·58	− ·09
W	250	55 24·08	− ·05	− ·15	− ·09	− ·03	− ·02	23·74	53 44·22	·52	+ ·03
	253	57 29·92	− ·05	− ·24	− ·09	− ·04	− ·02	29·48	55 50·03	·45	− ·04
	254	18 04 27·83	− ·04	− ·28	− ·09	− ·08	− ·02	27·32	18 02 47·83	·49	·00
	255	05 28·20	− ·04	− ·43	− ·10	− ·09	− ·02	27·52	03 48·05	·47	− ·02
	602	09 40·89	− ·05	− ·07	− ·10	− ·12	− ·02	40·53	08 01·09	·44	·05
	α Telescopii	21 30·98	− ·06	+ ·19	− ·13	− ·18	− ·03	30·77	19 51·19	·58	+ ·09

$a = +^{s}\cdot 450$ $c = +^{s}\cdot 089$

Chronometer correction at $17^{h}\ 50^{m} = -1^{m}\ 39^{s}\cdot 494 \pm {}^{s}\cdot 016$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	c.
W	603	18 50 58·76	− ·03	− ·02	− ·10	+ ·23	− ·02	58·82	18 49 18·66	−1 40·16	+ ·10
	267	56 56·48	− ·02	− ·30	·09	+ ·19	− ·02	56·24	55 16·18	·06	·00
	270	19 02 40·41	− ·02	− ·29	− ·09	+ ·16	− ·02	40·15	19 01 00·10	·05	·01
	ψ Sagittarii	11 19·41	− ·03	− ·03	− ·09	+ ·11	− ·02	19·35	09 39·29	·06	·00
	B.A.C. 6632	21 45·68	− ·04	+ ·31	− ·15	+ ·05	− ·03	45·82	20 05·85	39·97	·09
	α Vulpeculæ	26 23·80	− ·02	− ·37	− ·09	+ ·02	− ·02	23·32	24 43·24	40·08	+ ·02
E	ρ¹ Sagittarii	36 53·57	+ ·02	·09	+ ·09	− ·04	− ·02	53·53	35 13·53	40·00	·06
	277	43 22·31	+ ·02	·27	+ ·09	− ·08	− ·02	22·05	41 42·08	39·97	− ·09
	279	44 47·24	+ ·02	·32	+ ·09	·09	− ·02	46·92	43 06·91	40·01	− ·05
	ι Sagittarii	50 18·46	− ·02	+ ·13	+ ·11	− ·12	− ·02	18·58	48 38·43	·15	+ ·09
	283	52 16·51	+ ·01	− ·24	+ ·09	− ·13	− ·02	16·22	50 36·16	·06	·00
	286	56 10·27	·00	− ·33	+ ·09	− ·15	− ·02	09·86	54 29·79	·07	+ ·01
	287	20 08 01·84	·00	− ·20	+ ·09	− ·22	− ·02	01·49	20 06 21·34	·15	+ ·09

$a = +^{s}\cdot 418$ $c = +^{s}\cdot 085$

Chronometer correction at $19^{h}\ 30^{m} = -1^{m}\ 40^{s}\cdot 060 \pm {}^{s}\cdot 015$

TRANSIT OBSERVATIONS.

Station : NORFOLK ISLAND. Date, August 21st, 1903. Observer : F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·47	s.		h. m. s.	m. s.	s.
E	286	19 56 25·51	+ ·03	− ·47	+ ·04	+ ·28	− ·02	25·37	19 54 29·78	−1 55·59	− ·12
	c Sagittarii	58 40·58	+ ·04	·01	+ ·05	·26	− ·02	40·90	56 45·48	·42	− ·05
	287	20 08 16·94	+ ·04	·28	·04	− ·17	− ·02	16·89	20 06 21·34	·55	+ ·06
	607	14 39·35	+ ·04	·17	+ ·04	·13	− ·02	39·37	12 43·90	·47	·00
	608	17 32.73	+ ·04	− ·15	+ ·04	+ ·10	− ·03	32·73	15 37·31	·42	− ·05
	α Pavonis	19 58·42	+ ·06	+ ·51	+ ·07	+ ·09	− ·03	59·12	17 63·67	·45	− ·02
	609	25 18·70	+ ·05	− ·12	+ ·04	+ ·04	− ·02	18·69	23 23·33	·36	− ·11
W	297	44 24·92	− ·01	− ·20	·04	− ·11	− ·02	24·51	42 29·00	·54	+ ·07
	μ Aquarii	49 24 73	·00	− ·20	− ·04	− ·15	− ·02	24·32	47 28·87	·45	− ·02
	507	52 25·14	·00	·56	− ·05	·17	− ·02	24·34	50 28·96	·38	− ·09
	θ Capricorni	21 02 29·29	+ ·02	− ·12	·04	− ·26	− ·02	28·87	21 00 33·34	·53	+ ·06
	611	06 18·24	+ ·03	− ·18	− ·04	·29	− ·02	17·74	04 22·18	·56	+ ·09
	303	10 48·23	+ ·03	·58	− ·05	·31	·02	47·30	08 51·96	·34	·13

$a = -{}^{s}\cdot591$ $c = -{}^{s}\cdot040$

Chronometer correction at $20^h\ 30^m = -1^m\ 55^s\cdot468 \pm {}^s\cdot022$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	304	21 12 58·05	+ ·06	·17	− ·23	− ·22	− ·02	57·91	21 11 01·93	−1 55·98	− ·08
	θ¹ Microscopii	16 33·57	+ ·10	− ·08	− ·30	− ·19	− ·02	33 62	14 37·47	56·15	+ ·09
	307	28 26·88	+ ·07	− ·12	− ·23	+ ·11	− ·02	26·69	26 30·63	·06	·00
	ξ Aquarii	34 35·12	+ ·07	·11	− ·23	+ ·05	− ·02	34·88	32 38·85	·03	− ·03
E	615	43 40·64	+ ·14	− ·07	+ ·24	·02	− ·02	40·91	41 44·80	·11	+ ·05
	γ Gruis	50 02·83	+ ·14	+ ·06	+ ·29	·08	− ·02	03·22	48 07·22	·00	− ·06
	311	22 02 47·70	+ ·09	− ·14	+ ·23	− ·17	− ·02	47·69	22 00 51·55	·14	+ ·08
	α Gruis	04 07·00	+ ·11	+ ·14	+ ·34	− ·19	− ·03	07 37	02 11·55	·02	− ·04

$a = -{}^{s}\cdot298$ $c = -{}^{s}\cdot229$

Chronometer correction at $21^h\ 40^m = -1^m\ 56^s\cdot062 \pm {}^s\cdot020$

TRANSIT OBSERVATIONS.

Station : NORFOLK ISLAND. Date, August 22nd, 1903. Observer, F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction	v.
		h. m. s.	s.	s.	s.	r = s. ·28	s.		h. m. s.	m. s.	s.
E	241	17 32 30·23	+ ·05	- ·26	·19	+ ·13	·02	30·32	17 30 28·40	-2 01·92	+ ·05
	600	34 06·50	+ ·07	- ·09	+ ·20	- ·12	- ·02	06·78	32 04·94	·84	·03
	η Pavonis	38 18·98	+ ·13	- ·51	+ ·44	- ·10	·04	20·12	36 18·33	·79	08
	245	40 45·29	+ ·06	- ·21	+ ·19	·09	·02	45·40	38 43·51	·89	+ ·02
	246	44 44·03	+ ·04	·35	- 21	- ·07	·02	43·98	42 42·04	·94	·07
	250	55 45·96	+ ·07	- ·12	- ·19	+ ·02	·02	46·10	53 44·17	·93	·06
	253	57 51·80	+ ·06	- ·20	- ·19	- 01	- ·02	51·84	55 49·99	·85	·02
W	601	18 01 40·22	+ ·05	+ 01	·22	·00	- ·02	40 04	59 38·12	·92	+ ·05
	257	18 22·60	+ ·04	- ·17	- ·19	- ·09	·02	22·17	18 16 20·38	·79	·08
	α Telescopii	21 53·13	+ ·07	+ ·16	·27	- ·10	·03	52·96	19 51·13	·83	- ·04
	2 Aquilæ	39 03·27	+ ·05	- ·13	·19	- ·19	·02	02·79	37 01·02	77	- 10
	263	43 34·53	+ ·04	- ·30	·20	·20	- ·02	33·85	41 32·04	·81	06
	λ Pavonis	45 21·63	+ ·09	+ ·44	- ·41	- ·21	·04	21·50	43 19·54	·96	+ ·09

$a = -^s\!\cdot376$ $c = +^s\!\cdot189$

Chronometer correction at $18^h\ 00^m = -2^m\ 01^s\!\cdot866 \pm {}^s\!\cdot013$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction	v.
W	604	19 06 05·59	+ ·04	- ·07	- ·07	+ ·16	- ·02	05·63	19 04 03.24	-2 02·39	+ 05
	ψ Sagittarii	11 41·51	+ ·05	- ·03	·07	+ ·14	- ·02	41·58	09 39·26	·32	- ·02
	495	15 21·44	+ ·05	- ·31	- ·06	+ ·12	- ·02	21·22	13 18·85	·37	+ ·03
	B.A.C. 6632	22 07·73	- ·11	+ ·35	·11	+ ·08	- ·03	08·13	20 05·80	·33	- ·01
	α Vulpeculæ	26 45·88	- ·05	- ·42	- ·07	+ ·07	- ·02	45·49	24 43·20	·29	- 05
	275	28 54·31	+ ·04	- ·45	- ·07	+ ·06	- ·02	53 87	26 51·57	·30	·04
	605	32 54·32	+ ·08	- ·04	- ·07	+ ·04	- ·02	54·31	30 51·96	·35	+ ·01
E	277	43 44·54	+ ·12	- ·31	+ ·06	- ·01	·02	44·38	41 42·06	·32	- ·02
	ι Sagittarii	50 40·37	+ ·20	+ ·15	+ ·08	- ·05	- ·02	40·73	48 38·40	·33	- ·01
	283	52 38·65	+ ·14	- ·27	+ ·06	- ·06	- ·02	38 50	50 36·14	·36	+ ·02
	286	56 32·41	+ ·12	- ·37	+ ·07	- ·07	- ·02	32·14	54 29·77	·37	+ ·03
	c Sagittarii	58 47·55	+ ·21	·01	+ ·07	- ·09	- ·02	47·71	56 45·48	·23	- ·11
	287	20 08 23·89	+ ·18	- ·22	+ ·06	- ·14	- ·02	23·75	20 06 21·34	·41	+ ·07

$a = +^s\!\cdot474$ $c = +^s\!\cdot062$

Chronometer correction at $19^h\ 40^m = -2^m\ 02^s\!\cdot338 \pm {}^s\!\cdot010$

TRANSIT OBSERVATIONS.

Station: NORFOLK ISLAND. Date, August 23rd, 1903. Observer, F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R.A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − 30	s.		h. m. s.	m. s.	s.
E	λ Scorpii	17 29 13·89	− ·09	+ ·08	+ ·11	+ ·16	− ·02	14·13	17 27 04·89	2 09 24	+ ·02
	241.........	32 37 78	− ·06	− ·33	− ·09	− ·14	− ·02	37·60	30 28·39	·21	− ·01
	600..........	34 14·04	− ·07	− ·12	+ ·09	− ·13	− ·02	14·05	32 04 92	·13	− ·09
	η Pavonis	38 26 53	− ·14	+ ·67	+ ·20	·11	− ·04	27·33	36 18 29	·04	− ·18
	245..........	40 52·85	− ·06	− ·27	+ ·09	+ ·10	− ·02	52·69	38 43·49	20	− ·02
	246..........	44 51·51	− ·04	·46	+ ·10	− ·08	− ·02	51 17	42 42·02	·15	− ·07
	253..........	57 59 42	− ·06	·26	+ ·09	+ ·01	− ·02	59 18	55 49·98	·20	− ·02
W	601..........	18 01 47·70	− ·10	+ ·01	− 10	− ·01	− ·02	47·48	59 38·10	·38	+ ·16
	254..........	04 57·55	− ·06	·31	− ·09	·02	− ·02	57 05	18 02 47 77	·28	+ 06
	602..........	10 10·49	− ·09	− ·07	− ·09	·05	− ·02	10·17	08 01·03	·14	− ·08
	257..........	18 30·05	− ·07	− ·22	− 09	·10	− ·02	29·55	16 20·37	·18	− ·04
	ε Sagittarii .	19 57 43	− ·10	− ·06	− ·11	·10	− ·02	57·16	17 47·77	·39	+ ·17
	α Telescopii. ..	22 00·66	− ·11	− ·21	− ·13	− ·11	− ·03	00 49	19 51·12	·37	+ ·15
	λ Sagittarii... ..	24 12·08	− ·09	− ·03	− ·10	− ·12	− ·02	11·72	22 02·55	·17	− ·05

$a = -{}^{s}{\cdot}490$ $c = +{}^{s}{\cdot}088$

Chronometer correction at $18^{h}\ 00^{m} = -2^{m}\ 09^{s}{\cdot}220 \pm {}^{s}{\cdot}022$

TRANSIT OBSERVATIONS.

Station : NORFOLK ISLAND. Date, August 25th, 1903. Observer : F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R.A.	Chronometer correction.	[illegible]
		h. m. s.	s.	s.	s.	s. r = − ·35	s.		h. m. s.	m. s.	s.
E	η Pavonis . . .	17 38 42·21	+·04	+·54	+·04	+·36	−·04	43·15	17 36 18·21	−2 24·94	·01
	245.	41 08·21	+·02	−·22	+·02	+·35	−·02	08·36	38 43·46	·90	−·05
	246.	45 07·06	+·01	−·37	+.02	+·30	−·02	07·00	42 41·98	25·02	+07
	250.	56 08·95	+·02	−·13	+·02	+·26	−·02	09·10	53 44·13	24·97	+·02
	254.	18 05 12·66	+·01	−·25	+·02	+·20	·02	12·62	18 02 47·75	·87	08
W	602.	10 25·82	+·03	−·06	−·02	+·17	−·02	25·92	08 01·00	92	·03
	ε Sagittarii.	20 12·57	+·03	+·05	−·02	+·12	−·02	12·73	17 47 74	·99	·04
	283.	19 53 01·75	+·02	−·23	−·02	−·43	−·02	01·07	19 50 36·12	·95	·00
	286.	56 55·50	+·02	−·31	−·02	−·44	−·02	54·73	54 29 74	·99	+04
	c Sagittarii.	59 10·86	+·03	−·01	−·02	−·46	−·02	10·38	56 45·45	·93	02

$a = +^{s}\cdot398 \qquad c = +^{s}\cdot016$

Chronometer correction at $18^{h}\ 40^{m} = -2^{m}\ 24^{s}\cdot951 \pm {}^{s}\cdot011$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R.A.	Chronometer correction.	[illegible]
W	287	20 08 47·07	+·02	−·19	−·03	+·19	−·02	47·04	20 06 21·32	−2 25·72	+·08
	607.	15 09 52	+·03	·11	−·03	+·15	−·02	09·54	12 43·88	66	+·02
	608	18 02·79	+·03	·10	−·03	+·13	−·02	02 80	15 37·20	·60	·04
	α Pavonis	20 28 81	+·05	+·34	·05	+·12	−·03	29·24	18 03·63	·61	·03
	290.	31 03·92	+·02	−·26	·03	+·05	−·02	03·68	28 38·03	·65	+·01
	292.	35 29·27	+·02	·28	−·03	+·02	−·02	28·98	33 03 33	·65	·01
E	297.	44 54·74	+08	−.13	+·03	−·03	−·02	54·67	42 28 99	·68	·04
	μ Aquarii.	49 54·55	+·08	−·13	+·03	−·05	−·02	54·46	47 28·86	·60	·04
	507.	52 54·96	+·05	·37	+·03	·07	−·02	54·58	50 28·94	·64	·00
	ι Piscis Aust. . . .	57 50 11	+·09	+·03	+·03	−·10	−·02	50 14	55 24·47	67	+·03
	θ Capricorni. . . .	21 02 58·98	+·08	·08	+·03	−·13	−·02	58 86	21 00 33·34	·52	·12
	611.	06 47·98	+·08	−·12	+·03	−·14	−·02	47·81	04 22·18	·63	−01
	304.	13 27·91	+·07	−·22	+·03	·19	−·02	27·58	11 01·93	·65	+·01
	θ¹ Microscopii. . .	17 03·23	+10	+·11	+·04	−·22	−·02	03·24	14 37·48	·76	·12

$a = +^{s}\cdot394 \qquad c = +^{s}\cdot027$

Chronometer correction at $20^{h}\cdot 40^{m} = -2^{m}\ 25^{s}\cdot645 \pm {}^{s}\cdot013$

TRANSIT OBSERVATIONS.

Station: Norfolk Island. Date, August 27th, 1903. Observer: F. W. O. Werry.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R.A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	r = − s. ·30	s.		h. m. s.	m. s.	s.
E	λ Sagittarii ..	18 24 42·76	−·08	−·04	+·03	−·18	−·02	42·83	18 22 02·49	-2 40·34	·00
	[illegible] Aquilæ.	39 41·44	−·07	·17	+·03	−·10	·02	41·31	37 00·95	·36	+·02
	263..	44 12·66	−·05	·41	+·03	−·08	−·02	12·29	41 31·97	·32	−·02
	λ Pavonis	45 59·20	−·13	+·60	+·06	−·07	·04	59·76	43 19·41	·35	+·01
	603....	51 58·96	−·08	−·01	+·03	−·04	·02	58·92	49 18·56	·36	+·02
W	267............	57 56·87	−·07	−·36	−·03	+·01	−·02	56·40	55 16·09	·31	−·03
	270........... .	19 03 40·96	−·07	·35	−·03	−·02	·02	40·47	19 01 00·05	·42	−·08
	ζ Sagittarii....	12 19·68	−·10	−·04	−·03	·06	−·02	19·43	09 39·21	·22	−·12
	495..	15 59·64	−·07	−·33	−·03	·08	·02	59·11	13 18·80	·31	·03
	B.A.C. 6632....	22 46·06	−·14	·37	−·05	·12	·03	46·09	20 05·72	·37	+·03
	α Vulpeculæ....	27 24·20	−·06	−·45	−·03	−·13	−·02	23·51	24 43·14	·37	+·03

$a = +^{s}\cdot506 \qquad c = +^{s}\cdot028$

Chronometer correction at $19^{h}\,00^{m} = -2^{m}\,40^{s}\cdot339 \pm {}^{s}\cdot010$

TRANSIT OBSERVATIONS.

Station: Norfolk Island. Date, September 29th, 1903. Observer: F. W. O. Werry.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	r = − s. ·30.	s.		h. m. s.	s.	s.
E	615.....	21 41 52·68	−·04	−·06	−·15	−·19	·02	52·68	21 41 44·68	−08·00	−·06
	616.	22 01 23·49	+·01	−·07	−·14	−·09	−·02	23·36	22 01 15·38	07·98	−·08
	312......... ..	02 41·66	·00	−·26	−·15	+·09	−·02	41·32	02 33·23	08·09	+·03
	314.........	05 30·07	−·01	−·16	−·14	−·07	−·02	29·83	05 21·82	08·01	−·05
	α Toucani .	12 04·12	+·01	+·31	·29	−·04	−·04	04·15	11 56·00	08·15	+·09
	317......	16 50·51	−·01	−·13	−·14	−·02	−·02	50·25	16 42·21	08·04	−·02
	π Aquarii .	20 31·25	−·01	−·14	−·14	·00	−·02	30·96	20 22·86	08·10	+·04
W	σ Aquarii. . .	25 42·45	−·03	−·09	−·14	−·03	−·02	42·42	25 34·38	08·04	−·02
	320.......... .	30 33·94	−·03	−·14	−·14	−·05	−·02	33·84	30 25·79	08·05	−·01
	β Gruis....... .	37 04·34	−·04	+·14	+·21	−·08	−·03	04·54	36 56·52	08·02	−·04
	323.	42 03·54	−·02	−·25	+·15	−·11	−·02	03·29	41 55·16	08·13	+·07
	μ Pegasi.. .	45 31·34	−·02	−·25	−·15	−·13	−·02	31·07	45 22·96	08·11	+·05

$a = +^{s}\cdot289 \qquad c = -^{s}\cdot140$

Chronometer correction at $22^{h}\,20^{m} = -8^{s}\cdot059 \pm {}^{s}\cdot014$.

TRANSIT OBSERVATIONS.

Station: NORFOLK ISLAND. Date, October 1st, 1903. Observer: F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·25	s.		h. m. s.	s.	s.
E	θ Capricorni....	21 00 59·77	+ ·19	− ·09	− ·08	+ ·13	− ·02	59·90	21 00 33·05	−26·85	·04
	611........	04 48·73	+ ·17	− ·12	− ·08	+ ·11	− ·02	48·79	04 21·91	·88	·01
	304.......... .	11 28·69	+ ·15	− ·23	− ·08	+ ·08	− ·02	28·59	11 01·66	·93	+ ·04
	θ¹ Microscopii...	15 03·87	+ ·23	+ ·12	− ·11	+ ·06	− ·02	04·15	14 37·14	27·01	+ ·12
	ι Capricorni ...	17 20·99	+ ·19	− ·09	− ·08	+ ·05	− ·02	21·04	16 54·14	26·90	+ ·01
	γ Pavonis.. ...	18 56·81	+ ·35	+ ·60	− ·19	+ ·05	− ·04	57·58	18 30·74	·84	·05
	612............	21 37·97	+ ·19	− ·05	− ·09	+ ·04	− ·02	38·04	21 11·20	·84	·05
W	307..	26 57·28	+ ·08	− ·16	+ ·08	+ ·02	− ·02	57·28	26 30·43	·85	− ·01
	ξ Aquarii ...	33 05·44	+ ·08	− ·15	+ ·08	− ·01	− ·02	05·42	32 38·67	·75	·14
	ε Pegasi..	39 55·71	+ ·06	− ·26	+ ·08	− ·04	− ·02	55·53	39 28·61	·92	+ ·03
	615............	42 11·60	+ ·09	− ·09	+ ·08	·05	− ·02	11·61	41 44·65	·96	+ ·07
	γ Gruis	48 33·81	+ ·11	+ ·08	+ ·10	− ·08	− ·02	34·00	48 07·07	·93	+ ·04

$a = +^{s}\cdot412$ $c = -^{s}\cdot079$

Chronometer correction at $21^{h}\ 30^{m} = -26^{s}\cdot889 \pm {}^{s}\cdot015$

E	616........	22 01 42·55	+ ·13	− ·14	− ·08	+ ·20	− ·02	42·64	22 01 15·36	−27·28	+ ·06
	α Toucani	12 22·23	+ ·23	+ ·57	− ·16	+ ·15	− ·04	22·98	11 55·95	·03	·19
	317......	17 09·61	+ ·12	− ·24	− ·08	+ ·13	− ·02	09·52	16 42·19	·33	+ ·11
	π Aquarii.....	20 50·21	+ ·12	− ·26	− ·08	+ ·12	− ·02	50·09	20 22·84	·25	+ ·03
	β Gruis	37 23·49	+ ·19	+ ·25	− ·11	+ ·05	− ·03	23·84	36 56·50	·34	+ ·12
	323....	42 22·69	+ ·09	− ·45	− ·08	+ ·03	− ·02	22·26	41 55·15	·11	− ·11
W	μ Pegasi	45 50·39	+ ·03	− ·46	+ ·08	+ ·02	− ·02	50·04	45 22·94	·10	− ·12
	326.	48 04·01	+ ·05	− ·19	+ ·08	+ ·01	− ·02	03·94	47 36·73	·21	− ·01
	618.	50 00·88	+ ·05	− ·12	+ ·08	·00	− ·02	00·87	49 33·65	·22	·00
	329....	23 00 26·93	+ ·03	− ·37	+ ·08	− ·04	− ·02	26·61	59 59·34	·27	+ ·05
	621.............	38 12·53	+ ·02	− ·13	+ ·08	− ·19	− ·02	12·29	23 37 45·06	·23	+ ·01
	ι¹ Aquarii......	39 41·32	+ ·02	− ·10	+ ·08	− ·20	− ·02	41·10	39 13·81	·29	+ ·07

$a = +^{s}\cdot527$ $c = -^{s}\cdot076$

Chronometer correction at $22^{h}\ 50^{m} = -27^{s}\cdot219 \pm {}^{s}\cdot021$

TRANSIT OBSERVATIONS.

Station : NORFOLK ISLAND. Date, October 2nd, 1903. Observer : F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·35	s.		h. m. s.	s.	s.
E	616....	22 01 50·88	·00	− ·11	− ·10	+ ·16	− ·02	50·81	22 01 15·35	−35·46	+ ·07
	312.	03 08·93	·00	− ·38	− ·10	+ ·16	− ·02	08·59	02 33·20	·39	·00
	314.	05 57·51	·00	− ·24	− ·09	+ ·14	− ·02	57·30	05 21·80	·50	+ ·11
	α Toucani	12 30 94	·00	+ ·46	− ·19	+ ·11	− ·04	31·28	11 55·93	·35	− ·04
	317.....	17 17 71	00	− ·20	− ·09	+ ·08	− ·02	17·48	16 42·18	·30	− ·09
	π Aquarii	20 58 49	00	− ·21	− ·09	+ ·05	− ·02	58·22	20 22·84	·38	− ·01
W	β Gruis.........	37 31 68	− ·06	+ ·20	+ ·14	·04	− ·03	31·89	36 56·49	·40	+ ·01
	323 .	42 30·89	03	− ·37	+ ·10	− ·07	− ·02	30·50	41 55·14	·36	·03
	326...	48 12·42	− ·04	− ·15	+ ·09	10	02	12 20	47 36·72	·48	+ ·09
	618.....	50 09·19	− ·04	− ·10	+ ·10	·12	− ·02	09 01	49 33·64	·37	− ·02
	329.....	23 00 35 11	− ·03	− ·30	+ ·10	− ·18	− ·02	34·68	59 59·33	·35	·04
	620............	04 55 60	− ·04	− ·06	+ ·10	− ·20	− ·02	55·38	23 04 20 02	·36	− ·03

$a = -{}^{s}{\cdot}425 \quad c = -{}^{s}{\cdot}094$

Chronometer correction at $22^{h}\ 30^{m} = -35^{s}{\cdot}388 \pm {}^{s}{\cdot}013$

TRANSIT OBSERVATIONS.

Station : NORFOLK ISLAND. Date, October 3rd, 1903. Observer: F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·38	s.		h. m. s.	s.	s.
W	θ^1 Microscopii..	21 15 18·76	− ·02	+ ·12	+ ·15	+ ·22	− ·02	19·21	21 14 37·11	42·10	+ ·19
	ι Capricorni....	17 35·88	− ·01	− ·09	+ ·12	+ ·21	− ·02	36·09	16 54·11	41·98	+ ·07
	γ Pavonis. ...	19 11·59	− ·02	+ ·62	+ ·27	+ ·20	− ·04	12·62	18 30·67	·95	+ ·04
	612............	21 52·92	− ·01	·05	+ ·12	+ ·18	− ·02	53·14	21 11·18	·96	+ ·05
	307............	27 12·26	− ·01	− 16	+ ·11	+ 15	− ·02	12·33	26 30·41	·92	+ ·01
	ξ Aquarii.. ...	33 20·56	− ·01	·15	+ ·11	+ ·11	− ·02	20·60	32 38·65	·95	+ ·04
E	616.	22 01 57·48	+ ·05	− ·11	− ·11	− ·07	− ·02	57 22	22 01 15·34	·88	− ·03
	312......... ..	03 15·61	+ ·03	− ·38	− ·12	·08	− ·02	15·04	02 33·19	·85	− ·06
	314.......	06 04·04	+ ·04	− 24	·11	− ·10	− ·02	03 61	05 21·79	·82	− ·09
	α Toucani	12 37 53	+ ·09	+ ·46	− ·23	·14	− ·04	37·67	11 55·91	·76	·15
	317.............	17 24·55	+ ·04	− ·19	·11	·17	− ·02	24·10	16 42·18	·92	·01
	π Aquarii	21 05·24	+ ·04	− ·21	− ·11	− ·20	− ·02	04·74	20 22·83	·91	·00

$a = +^{s}\cdot423$ $c = -^{s}\cdot111$

Chronometer correction at $21^{h}50^{m} = -41^{s}\cdot915 \pm {}^{s}\cdot018$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
E	σ Aquarii ...	22 26 16·59	+ ·06	− ·13	− ·08	+ ·28	− ·02	16·70	22 25 34·32	−42·38	·02
	320.	31 08·22	+ ·06	− ·19	− ·08	+ ·25	− ·02	08·24	30 25·76	·48	+ ·08
	β Gruis	37 38·45	+ ·09	+ ·19	− ·11	+ ·21	− ·03	38·80	36 56·48	·32	− ·08
	323............	42 37·80	+ ·04	− ·35	− ·08	+ ·18	·02	37·57	41 55·13	·44	+ ·04
	μ Pegasi.......	46 05·49	+ ·04	− ·36	− ·08	+ ·15	− ·02	05·22	45 22·93	·29	− ·11
	ϕ Aquarii.	23 10 04·12	+ ·06	− ·16	− ·08	·00	− ·02	03·92	23 09 21·47	·45	+ ·05
	γ Toucani.......	12 32·45	+ ·11	+ ·39	− ·15	·01	− ·04	32·75	11 50·29	·46	+ ·06
W	534.............	22 43·89	− ·02	·20	+ ·08	− ·08	− ·02	43·56	22 01·15	·41	+ ·01
	333.	35 44·11	·02	− ·23	+ ·08	·16	− ·02	43·76	34 61·28	·48	+ ·08
	621.......... ...	38 27·62	·02	− ·10	+ ·08	− ·18	− ·02	27·38	37 45·06	·32	− ·08
	ι^1 Aquarii......	39 56·42	− ·02	− ·08	+ ·08	− ·18	− ·02	56·20	39 13·80	·40	·00

$a = +^{s}\cdot405$ $c = -^{s}\cdot077$

Chronometer correction at $23^{h}10^{m} = -42^{s}\cdot404 \pm {}^{s}\cdot020$

TRANSIT OBSERVATIONS.

Station: Norfolk Island. Date, October 8th, 1903. Observer: F. W. O. Werry.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·36	s.		h. m. s.	m. s.	s.
E	σ Aquarii. . . .	22 27 02 53	+ ·07	− ·15	− ·18	− ·38	− ·02	02 63	22 25 34·30	−1 28·33	− 01
	320.	31 54 16	· 07	− ·23	− ·18	+ ·35	− ·02	54·15	30 25·73	·42	− ·08
	β Gruis	38 24 41	+ ·10	+ 23	− ·27	+ ·31	− ·03	24·75	36 56·42	·33	− ·01
	329.	23 01 28 02	+ ·05	· ·35	·19	+ ·17	− ·02	27·68	59 59 30	·38	+ ·04
	620.	05 48 36	+ ·08	− 07	− ·19	+ ·14	− ·02	48 30	23 04 20·00	·30	− ·04
	φ Aquarii	10 49·92	− 07	− ·19	− ·18	+ ·11	− ·02	49 71	09 21·46	·25	− ·09
	γ Toucani .	13 18·29	+ ·13	+ ·47	− ·35	+ ·10	− ·04	18·60	11 50·24	·36	+ ·02
W	531.	17 22·38	− 02	− ·50	+ ·20	+ ·07	− ·02	22·11	15 53·87	·24	− ·10
	622.	45 24 40	− ·02	− ·01	+ ·21	·09	− ·02	24·47	43 55·93	·54	+ ·20
	336.	55 52·17	− ·02	35	+ ·18	· ·15	− ·02	51·81	54 23·45	·36	+ ·02
	2 Ceti	24 00 18·31	− ·02	− ·12	+ ·19	− ·17	− ·02	18·17	58 49 80	·37	+ ·03
	33 Piscium.	01 54 47	·02	·23	+ ·18	·19	− ·02	54·19	24 00 25·84	·35	+ ·01
	3	09 47·05	− 02	− ·42	− ·19	− ·24	− ·02	46·54	08 18·21	·33	− ·01
	ζ Toucani.	16 32·92	− ·04	+ ·84	− ·43	− ·28	− ·04	33 83	15 05·55	·28	− ·06

$a_1 = -^s{\cdot}489$, $a_2 = -^s{\cdot}587$ $c = -^s{\cdot}180$

Chronometer correction at $23^h\ 30^m = -1^m\ 28^s{\cdot}345 \pm {}^s{\cdot}015$

TRANSIT OBSERVATIONS.

Station: NORFOLK ISLAND. Date, October 11th, 1903. Observer: F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·22	s.		h. m. s.	m. s.	s.
E	γ Gruis	21 50 01 35	+ ·12	+ ·08	− ·20	+ ·15	− ·02	01·48	21 48 06·93	−1 54·55	+ ·08
	616	22 03 09·85	+ ·09	− ·11	− ·16	+ ·10	− ·02	09·75	22 01 15·25	·50	+ ·03
	312	04 27·81	+ ·06	− ·37	− ·17	+ ·09	− ·02	27·40	02 33·09	·31	− ·16
	314	07 16·46	+ ·08	− ·23	− ·16	+ ·08	− ·02	16·21	05 21·70	·51	+ ·04
	α Toucani	13 49·79	+ ·17	+ ·45	− ·32	+ ·06	− ·04	50·11	11 55·72	·39	·08
	π Aquarii	22 17·57	+ ·08	− ·21	·16	+ ·03	− ·02	17·29	20 22·75	·54	+ ·07
	σ Aquarii	27 28·94	+ ·09	− ·13	− ·16	+ ·01	− ·02	28·73	25 34·24	·49	+ ·02
W	β Gruis	38 50·49	− ·05	+ ·20	+ ·23	− ·03	− ·03	50·81	36 56·37	·44	− ·03
	323	43 49 78	− ·02	− ·36	+ ·17	− ·05	− ·02	49·50	41 55·07	·43	·04
	μ Pegasi	47 17·69	− ·02	− ·37	+ ·17	− ·06	− ·02	17 39	45 22·89	50	+ ·03
	326	49 31·28	− ·03	− ·15	+ ·16	− ·07	− ·02	31·17	47 36·66	·51	+ ·04
	618	51 28·18	− ·03	− ·10	+ ·16	− ·08	− ·02	28·11	49 33·58	·53	+ ·06
	329	23 01 53·92	− ·02	− ·30	+ ·16	− ·11	− ·02	53·63	59 59·28	·35	·12
	620	06 14·53	− ·04	− ·06	+ ·17	− ·13	− ·02	14·45	23 04 19·98	·47	·00

$a = -^{s}\cdot415 \qquad c = -^{s}\cdot156$

Chronometer correction at $22^{h}\ 30^{m} = -1^{m}\ 54^{s}\cdot468 \pm {}^{s}\cdot016$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	620	23 06 14·53	− ·03	− ·09	+ ·16	+ ·16	− ·02	14·71	23 04 19·98	−1 54·73	− ·04
	φ Aquarii	11 16·08	− ·02	− ·24	+ ·15	+ ·14	− ·02	16·09	09 21·44	·65	− 12
	γ Toucani	13 44·05	− ·04	+ ·58	+ ·15	+ ·14	− ·04	44·84	11 50·18	·66	− ·11
	621	39 39·79	− ·02	− ·12	+ ·15	+ ·04	− ·02	39·82	37 45·04	·78	+ ·01
	ι¹ Aquarii	41 08·53	− ·03	− ·15	+ ·15	+ ·03	− ·02	08·51	39 13·78	·73	− ·04
	622	45 50·66	− ·03	− ·01	+ ·17	+ ·03	− ·02	50·80	43 55 91	·89	+ ·12
E	2 Ceti	24 00 44·77	+ ·06	− ·12	− ·15	− ·04	− ·02	44·50	58 49·79	·71	− ·06
	33 Piscium	02 20·88	+ ·06	− ·24	− ·15	− ·04	− ·02	20·49	24 00 25·83	·66	− ·11
	ζ Toucani	16 59·76	+ ·13	+ ·87	− ·35	− ·10	− ·04	60·27	14 65·53	·74	− ·03
	44 Piscium	22 24·80	+ ·06	− ·31	− ·15	− ·12	− ·02	24·26	20 29·47	·79	+ ·02
	339	27 04·24	+ ·06	− ·25	− ·15	− ·14	− ·02	03·74	25 08·88	·86	+ ·09
	13 Baleine	32 14·26	+ ·06	− 26	− ·15	− ·15	− ·02	13·74	30 18·95	·79	+ ·02
	130 Piazzi	34 20·44	+ ·07	− ·04	− ·16	− ·16	− ·02	20·13	32 25 27	·86	+ ·09

$a = +^{s}\cdot669 \qquad c = -^{s}\cdot146$

Chronometer correction at $23^{h}\ 50^{m} = -1^{m}\ 54^{s}\cdot770 \pm {}^{s}\cdot017$

TRANSIT OBSERVATIONS.

Station : NORFOLK ISLAND. Date, October 12th, 1903. Observer, F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − 26	s.		h. m. s.	m. s.	s.
E	616........ . .	22 03 16·11	·14	− ·11	·12	− ·14	− ·02	16 14	22 01 15·24	−2 00·90	+ ·02
	312	04 34 21	·09	− 39	− 13	+ ·13	− ·02	33·89	02 33·08	·81	− ·07
	314.	07 22 76	+ ·12	·25	− ·12	·12	− ·02	22·61	05 21 69	·92	− ·04
	α Toucani..	13 56 03	+ ·25	+ ·47	25	+ ·09	− ·04	56·55	11 55·69	·86	− ·02
	317............	18 43 12	·13	·20	− ·12	+ ·07	·02	42·98	16 42·09	·89	+ ·01
	π Aquarii.....	22 23·80	+ ·13	·22	·12	+ 05	− ·02	23·62	20 22·74	·88	·00
	320.............	32 26·82	+ ·13	21	− ·12	+ ·01	− ·02	26·61	30 25·69	·92	+ ·04
W	β Gruis ..	38 56·74	+ ·11	+ ·20	+ ·18	·02	− ·03	57·18	36 56·35	·83	− ·05
	326	49 37 57	+ 08	·16	+ ·12	− ·06	− ·02	37·53	47 36·64	89	+ ·01
	618.............	51 34 47	+ ·08	·10	+ ·13	·07	− ·02	34·49	49 33·57	·92	+ ·04
	329...........	23 02 00·34	+ 06	− 31	+ ·12	·11	− ·02	00 08	59 59·27	·81	− ·07
	620.	06 20 90	+ ·06	·06	+ ·13	− 13	− ·02	20·88	23 04 19·97	·91	+ ·03

$a = +^{s}\cdot440$ $c = -^{s}\cdot121$.

Chronometer correction at $22^h\ 35^m = -2^m\ 00^s\cdot877 \pm^s\cdot009$.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	φ Aquarii...	23 11 22·39	+ ·03	− ·18	+ ·18	+ ·30	− ·02	22·70	23 09 21·43	−2 01·27	·08
	γ Toucani	13 50 56	− ·06	+ ·44	+ ·35	+ ·29	− ·04	51·66	11 50·17	·49	+ ·14
	3	24 10 19 65	+ ·03	− ·33	+ ·19	+ ·04	− ·02	19 56	24 08 18·21	·35	·00
	ζ Toucani	17 05 62	+ ·07	+ ·65	+ ·41	+ ·01	− ·04	06·75	15 05·51	·24	− ·11
	44 Piscium......	22 30·87	·03	− ·23	+ ·18	− ·01	− ·02	30·82	20 29·48	·34	− ·01
	339............	27 10·32	+ ·03	− ·19	+ ·18	− 03	− ·02	10·29	25 08·88	·41	+ ·06
E	13 Baleine......	32 20·54	·13	− ·19	− ·18	− ·05	− ·02	20·23	30 18·95	·28	− ·07
	540.,......	40 48·31	− ·15	− ·09	− ·19	− ·09	− ·02	48·07	38 46·72	·35	·00
	11.....	44 17·78	− ·10	− ·40	− ·20	− ·11	− ·02	17·15	42 15·83	·32	− ·03
	342..........	45 44 57	·12	− ·27	− ·18	·12	− ·02	44·10	43 42·74	·36	+ ·01
	ζ² Piscium...	25 10 45·56	+ ·12	− ·27	− ·18	− ·22	− ·02	44·99	25 08 43·56	·43	− ·08

$a = +^{s}\cdot461$ $c = -^{s}.182$

Chronometer correction at $24^h\ 20^m = -2^m\ 01^s\cdot348 \pm^s\cdot019$

TRANSIT OBSERVATIONS.

Station: NORFOLK ISLAND. Date, October 16th, 1903. Observer, F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·20	s.		h. m. s.	m. s.	s.
E	α Toucani..	22 14 23 09	+ ·19	+ ·45	·50	·10	− ·04	23 29	22 11 55·58	−2 27·71	·01
	317	19 10·08	+ ·10	− ·19	− ·24	+ ·09	− ·02	09·82	16 42 05	·77	+ ·05
	π Aquarii.......	22 50·69	+ ·10	− ·21	·24	+ ·08	− ·02	50·40	20 22 70	·70	− ·02
	σ Aquarii......	28 02·13	+ ·11	·13	·25	+ ·06	− ·02	01·90	25 34·19	·71	·01
	320............	32 53·72	+ ·10	− ·20	·20	+ ·05	− ·02	53·45	30 25·66	·79	+ ·07
	β Gruis........	39 24·05	+ ·15	+ ·19	− ·36	+ ·02	− ·03	24·02	36 56·29	·73	+ .01
	323	44 23·29	+ ·07	− ·36	·27	·00	− ·02	22.71	41 55·02	·69	− ·03
W	μ Pegasi........	47 50·54	+ ·03	− ·36	+ ·27	− ·01	− ·02	50·45	45 22·81	·64	·08
	326...	50 04·26	+ ·05	− ·15	+ ·25	− ·02	− ·02	04·37	47 36·62	·75	+ ·03
	618............	52 01·07	+ ·05	− ·10	+ ·25	− ·02	·02	01·23	49 33·54	·69	·03
	329	23 02 27·09	+ ·04	− ·29	+ ·25	− ·06	− ·02	27·01	59 59·24	·77	+ ·05
	620............	06 47·53	+ ·05	− ·06	+ .26	− ·07	− ·02	47·69	23 04 19·94	·75	+ ·03
	φ Aquarii....	11 49·13	+ ·05	− ·16	+ ·25	− ·09	− ·02	49·16	09 21·40	·76	+ ·04
	γ Toucani.....	14 17·00	+ ·08	+ ·40	+ ·47	− ·10	− ·04	17·81	11 50 10	·71	·01

$a = +^s{\cdot}414$ $c = -^s{\cdot}241$

Chronometer correction at $22^h\ 45^m = -2^m\ 27^s{\cdot}723 \pm {}^s{\cdot}008$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	534........	23 24 28·98	+ ·06	− ·31	+ ·30	+ ·14	− ·02	29·15	23 22 01·10	−2 28·05	+ ·07
	535	26 46·37	+ ·05	·42	+ ·31	+ ·13	− ·02	46·42	24 18·52	27·90	− ·08
	538............	50 04·94	+ ·05	− ·49	+ ·32	+ ·05	− ·02	04 85	47 36·94	27·91	·07
	336............	56 51·47	+ ·06	·37	+ ·31	+ ·03	− ·02	51·48	54 23·44	28·04	+ ·06
	2 Ceti.	24 01 17·60	+ ·07	− ·12	+ ·32	+ ·01	− ·02	17·86	58 49·78	28·08	+ ·10
	33 Piscium......	02 53·62	+ ·06	·24	+ ·31	+ ·01	− ·02	53·74	24 00 25·82	27·92	− ·06
	3	10 46·31	+ ·05	− ·44	+ ·31	·02	− ·02	46·19	08 18·21	27·98	·00
E	ζ Toucani....	17 33·11	+ ·22	+ ·89	− ·73	− ·04	− ·04	33·41	15 05·47	27·94	− ·04
	44 Piscium	22 58·02	+ ·10	·32	− ·30	− ·06	− ·02	57·42	20 29·47	27·95	− ·03
	α Phœnicis.....	24 01·20	+ ·15	+ ·20	·41	− ·06	− ·03	01·05	21 32·97	28·08	+ ·10
	339............	27 37·43	+ ·10	− ·26	− ·30	− ·07	− ·02	36·88	25 08·89	27·99	+ ·01
	13 Baleine.. ..	32 47·51	+ ·10	− ·26	− ·30	− ·09	− ·02	46·94	30 18·96	27·98	·00
	130 Piazzi.......	34 53·66	+ ·13	− ·04	− ·34	− ·10	− ·02	53·29	32 25·28	28·01	+ ·03
	342......	46 11·44	+ ·09	− ·37	·31	− ·14	− ·02	10·69	43 42·75	27·94	− ·04

$a = +^s{\cdot}623$ $c = -^s{\cdot}304$

Chronometer correction at $24^h\ 05^m = -2^m\ 27^s{\cdot}982 \pm {}^s{\cdot}015$

TRANSIT OBSERVATIONS.

Station: Southport. Date, September 25th, 1903. Observer: Otto Klotz.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. ·12	s.		h. m. s.	s.	s.
E	μ Aquarii	20 46 55·57	+ ·10	− ·03	− ·25	− ·22	− ·02	55·59	20 47 28·61	+ 33·02	− ·01
	32 Vulpeculae	49 55·83	+ ·06	·09	− ·28	·19	− ·02	55·69	50 28·66	32·97	+ ·04
	θ Capricorni	21 00 00·14	+ ·10	− ·02	− ·26	− ·14	− ·02	00·08	21 00 33·13	33·05	− ·04
	ζ Cygni	08 18·91	+ ·06	− ·09	− ·29	− ·10	− ·02	18·67	08 51·70	33·03	− ·02
	α Equulei	10 28·95	+ ·08	− ·05	− ·25	− ·09	− ·02	28·80	11 01·79	32·99	+ ·02
W	β Aquarii	25 57·55	·19	− ·04	+ ·25	− ·02	− ·02	57·57	26 30·55	32·98	+ ·03
	ξ Aquarii	32 05·74	− ·19	− ·03	+ ·25	·02	− ·02	05·73	32 38·73	33·00	+ ·01
	ε Pegasi	38 55·71	− ·16	− ·06	+ ·25	− ·05	− ·02	55·67	39 28·68	33·01	·00
	α Toucani	22 11 22·99	·34	+ ·10	+ ·52	− ·22	− ·04	23·01	22 11 56·06	33·05	− ·04

$a = -{}^{s}\cdot093 \qquad c = -{}^{s}\cdot151$

Chronometer correction at $21^{h}\ 28^{m} = +33^{s}\cdot010 \pm {}^{s}\cdot008$

TRANSIT OBSERVATIONS.

Station : SOUTHPORT. Date, September 29th, 1903. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·40	s.		h. m. s.	s.	s.
E	β Pavonis	20 36 16·66	− ·08	− ·68	·32	− ·24	·05	17·13	20 36 18·15	+01·02	+ ·11
	ε Cygni	42 19·60	·02	·59	− ·18	− 20	− ·03	18·98	42 20·17	·19	− ·06
	μ Aquarii......	47 27·58	− ·04	− ·14	·13	− ·17	− ·02	27·42	47 28·56	·14	− ·01
	ι Piscis Aust...	55 23·00	·05	+ ·04	− ·15	− ·11	·02	22 93	55 24·15	·22	− ·09
	θ Capricorni....	21 00 32·03	− ·04	− ·08	·14	− ·08	·02	31·83	21 00 33·08	·25	− ·12
	ν Aquarii ...	04 21·08	·04	− ·12	− ·13	− ·05	− ·02	20·82	04 21·94	·12	− ·01
	ζ Cygni	08 51 14	− ·03	− ·42	·15	− ·03	− ·02	50·55	08 51·63	·08	+ ·05
W	γ Pavonis	18 29·16	·43	+ ·66	− ·31	04	− ·05	29·61	18 30·81	·20	− ·07
	ζ Capricorni....	21 10·42	− ·25	− ·04	+ ·14	− ·06	− ·02	10·19	21 11·28	·09	+ ·04
	β Aquarii	26 29·82	·21	− ·17	− ·13	− ·09	− ·02	29·46	26 30·51	·05	+ ·08
	ξ Aquarii	32 37·94	− ·22	− ·15	+ ·13	− ·13	·02	37·55	32 38·69	·14	− ·01
	ε Pegasi	39 28·08	·18	− ·27	+ ·13	·18	− ·02	27·56	39 28·64	·08	− ·05
	δ Capricorni....	41 44·09	− ·23	− ·09	− ·13	− ·19	·02	43·69	41 44·72	·03	+ ·10
	γ Gruis.........	48 06·15	− ·29	+ ·10	− ·16	·24	− ·02	05·86	48 07·10	·24	·11

$a = -^{s}\cdot437$ $c = \;^{s}\cdot129$

Chronometer correction at $21^{h}\ 12^{m} = +1^{s}\cdot132 \pm {}^{s}\cdot015$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	κ Piscium	23 22 01·24	·13	− ·25	− ·10	− ·29	− ·02	01·23	23 22 01·20	−00·03	− ·03
	ι Phœnicis	29 54 97	− ·19	+ ·19	− ·13	− ·25	− ·03	55·32	29 55·14	·18	+ ·12
	ι Piscium	35 01·50	·12	·28	− ·10	− ·20	− ·02	01·38	35 01·30	·08	+ ·02
	δ Sculptoris	43 55·99	− ·17	− ·01	− ·11	− ·15	− ·02	56·07	43 56·01	·06	·00
	ω Piscium.......	54 23·76	− ·12	− ·29	+ ·10	− ·08	− ·02	23·51	54 23·48	·03	·03
	2 Ceti..........	58 49·91	− 15	− ·09	− ·10	− ·05	− ·02	49·80	58 49·79	·01	− ·05
	γ Pegasi	24 08 18·54	− ·11	·41	+ ·10	− ·01	− ·02	18·09	24 08 18·23	+ ·14	·20
E	β Hydri........	20 43·77	− ·48	+1·85	− ·46	− ·09	− ·09	45·46	20 45·45	− ·01	− ·05
	12 Ceti..........	25 09·34	+ ·14	− ·21	·10	− ·13	− ·02	09.02	25 08·90	·12	+ ·06
	ε Andromedæ ..	33 30·59	− ·10	·49	− ·11	− ·18	− ·02	29·89	33 29·85	·04	− ·02
	β Ceti.... ...	38 47·03	− ·16	− ·09	− ·10	− ·21	− ·02	46·77	38 46·72	·05	·01
	δ Piscium	43 43·28	− ·13	− ·30	− ·10	− ·25	− ·02	42·74	43 42·65	·09	+ ·03
	20 Ceti..........	48 07·24	− ·14	− ·23	− ·10	− ·28	− ·02	06·75	48 06·61	·14	+ ·08
	μ Andromedæ ..	51 27·52	+ ·08	− ·60	− ·12	− ·29	− ·02	26·57	51 26·56	·01	− ·05

$a = +^{s}\cdot513$ $c = -^{s}\cdot097$

Chronometer correction at $24^{h}\ 06^{m} = -{}^{s}\cdot056 \pm {}^{s}\cdot015$

TRANSIT OBSERVATIONS.

Station: SOUTHPORT. Date, September 30th, 1903. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = −·47	s.		h. m. s.	s.	s.
E	β Pavonis......	20 36 27·98	+·04	+·68	−·17	+·26	−·05	28·74	20 36 18·46	−10·28	−·04
	ε Cygni..	42 30·80	+·01	−·46	−·08	+·21	−·02	30·46	42 20·15	·31	−·01
	μ Aquarii......	47 38·93	+·02	−·14	−·07	+·17	−·02	38·89	47 28·54	·35	−·03
	ι Piscis Aust...	55 34·45	+·03	+·04	−·08	+·11	−·02	34·53	55 24·14	·39	+·07
	ν Aquarii.....	21 04 32·39	+·02	−·12	−·07	+·04	−·02	32·24	21 04 21·92	·32	·00
	ζ Cygni... ...	09 02·45	+·02	−·42	−·08	·00	−·02	01·95	08 51·63	·32	·00
W	γ Pavonis.......	18 40·77	−·36	+·65	+·16	·07	−·05	41·10	18 30·78	·32	·00
	ζ Capricorni....	21 21·87	−·20	−·04	+·07	−·09	−·02	21·59	21 11·27	·32	·00
	β Aquarii.....	26 41·21	−·17	−·16	+·07	−·13	−·02	40·80	26 30·50	·30	·02
	ξ Aquarii.....	32 49·50	−·17	−·15	+·07	−·18	−·02	49·05	32 38·68	·37	+·05
	ε Pegasi..	39 39·51	−·15	−·27	+·07	·24	−·02	38·90	39 28·63	·27	−·05
	δ Capricorni....	41 55·48	−·19	−·09	+·07	−·26	−·02	54·99	41 44·71	·28	−·04

$a = -{}^{s}\cdot436$ $c = -{}^{s}\cdot067$

Chronometer correction at $21^{h}\ 09^{m} = -10^{s}\cdot319 \pm {}^{s}\cdot008$

TRANSIT OBSERVATIONS.

Station: SOUTHPORT. Date, October 1st, 1903. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = −·53	s.	s.	h. m. s.	s.	s.
E	e^2 Aquarii.. ...	23 04 43·82	·03	·05	−·15	·40	−·02	43·97	23 04 20·06	−23·91	+·02
	γ Toucani......	12 13·81	·05	−·40	−·26	−·31	−·04	14·17	11 50·31	·86	·03
	τ Pegasi.......	16 18·02	·02	·35	−·15	−·28	·02	17·76	15 53·91	·85	·04
	κ Piscium......	22 25·22	−·03	·20	−·14	−·24	·02	25·07	22 01·20	·87	·02
	ι Phœnicis.....	30 19·04	−·04	·15	−·19	−·17	−·03	19·10	29 55·13	·97	−·08
	ι Piscium.....	35 25·43	−·03	·22	·14	−·12	·02	25·14	35 01·32	·82	·07
	δ Sculptoris....	44 20·03	−·03	·00	·16	−·04	·02	19·86	43 55·96	·90	+·01
W	ω Piscium......	54 47·52	+·01	−·23	−·14	−·04	−·02	47·38	54 23·49	·89	·00
	γ Pegasi........	24 08 42·45	+·01	−·29	−·14	·15	·02	42·14	24 08 18·24	·90	+·01
	ι Ceti..... ...	14 56·78	+·01	·13	−·14	·22	·02	56·56	14 32·68	·88	·01
	β Hydri..... ..	21 07·52	·03	+1·48	−·65	−·28	·09	09·31	20 45·43	·88	−·01
	12 Ceti.........	25 33·21	·01	−·16	−·14	−·31	−·02	32·87	25 08·90	·97	+·08
	ε Andromedæ..	33 54·36	·01	·39	−·16	−·40	·02	53·72	33 29·86	·86	−·03

$a = +{}^{s}\cdot409$ $c = -{}^{s}\cdot137$

Chronometer correction at $23^{h}\ 49^{m} = -23^{s}\cdot890 \pm {}^{s}\cdot009$

TRANSIT OBSERVATIONS.

Station: SOUTHPORT. Date, October 2nd, 1903. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·596	s.		h. m. s.	s.	s.
E	μ Aquarii......	20 48 03·00	− ·01	− ·15	− ·16	+ ·37	− ·02	03·03	20 47 28·51	−34·52	+ ·08
	32 Vulpeculæ...	51 03·22	·00	− ·45	− ·18	+ ·34	− ·02	02·91	50 28·54	·37	− ·07
	1 Piscis Aust....	55 58·45	− ·01	+ ·05	− ·19	+ ·30	− ·02	58·58	55 24·11	·47	+ ·03
	θ Capricorni	21 01 07·50	− ·01	− ·09	− ·16	+ ·24	− ·02	07·46	21 00 33·04	·42	− ·02
	ν Aquarii.....	04 56·49	− ·01	− ·14	− ·16	+ ·21	− ·02	56·37	04 21·89	·48	+ ·04
	γ Pavonis......	19 04·78	− ·02	+ ·73	− ·38	+ ·06	− ·05	05·12	18 30·70	·42	− ·02
W	β Aquarii.......	27 05·35	− ·32	− ·18	+ ·16	− ·02	− ·02	04·97	26 30·48	·49	+ ·05
	ε Pegasi...	40 03·46	·19	− ·30	+ ·16	− ·15	− ·02	02·96	39 28·60	·36	− ·08
	δ Capricorni . ..	42 19·53	− ·25	− ·10	+ ·16	− ·17	− ·02	19·15	41 44·69	46	+ ·02
	α Aquarii	22 01 26·61	− ·22	− ·22	+ ·16	− ·36	− ·02	25·95	22 00 51·50	·45	+ ·01
	α Gruis.......	02 45·92	− ·35	+ ·24	+ ·23	− ·37	− ·03	45·64	02 11·20	·44	.00

$a = +^{s}{\cdot}484$ $c = {}^{s}{\cdot}156$

Chronometer correction at $21^h\ 25^m = -34^s{\cdot}442 \pm {}^s{\cdot}012$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	α Pegasi. ...	23 00 34·96	+ ·05	− ·30	+ ·07	+ ·54	− ·02	35·30	22 59 59·36	−35·94	·01
	c^2 Aquarii......	04 55·47	+ ·07	− ·05	+ ·07	+ ·50	− ·02	56·04	23 04 20·06	·98	+ ·03
	τ Pegasi........	16 29·73	+ ·04	36	+ ·08	+ ·38	− ·02	29·85	15 53·91	·94	− 01
	κ Piscium... ...	22 36·87	+ 06	·20	+ ·07	+ ·32	− ·02	37·10	22 01·19	·91	·04
	ι Phœnicis... ..	30 30·60	+ ·10	+ ·16	+ ·09	+ ·24	− ·03	31·16	29 55·13	36·03	+ ·08
	ι Piscium	35 37·14	+ ·06	− ·23	+ ·07	+ ·19	− ·02	37·21	35 01·30	35·91	·04
	δ Sculptoris. ...	44 31·70	+ ·07	·00	+ ·08	+ ·10	− ·02	31·93	43 56·01	·92	− 03
E	α Andromedæ...	24 04 02·98	+ ·06	− ·40	·08	− ·10	− ·02	02·44	24 03 26·44	36·00	+ 05
	ι Ceti..	15 08·99	+ ·09	·14	·07	− ·21	− ·02	08·64	14 32·68	35·96	+ ·01
	β Hydri........	21 20·24	+ ·29	+1·53	− ·33	− ·27	− ·09	21·37	20 45·44	·93	− ·02
	12 Ceti.........	25 45·35	− ·09	·17	·07	− ·31	− ·02	44·87	25 08·90	·97	+ ·02
	ε Andromedæ...	34 06·62	+ ·06	·40	− 08	− ·40	− ·02	05·78	33 29 87	·91	− ·04
	δ Piscium.......	44 19·39	+ ·08	·25	·07	− ·50	− ·02	18·63	43 42·67	·96	− ·01
	20 Ceti.....	48 43·31	+ 09	− ·19	− ·07	·54	− ·02	42·58	48 06 63	·95	·90

$a = +^{s}{\cdot}424$ $c = -{}^{s}{\cdot}069$

Chronometer correction at $23^h\ 54^m = -35^s{\cdot}952 \pm {}^s{\cdot}007$

TRANSIT OBSERVATIONS.

Station: SOUTHPORT. Date, October 3rd, 1903. Observer: OTTO KLOTZ

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·49	s.		h. m. s.	s.	s.
E	α Pavonis......	20 18 49·96	+ ·07	+ ·30	− ·25	+ ·34	− ·04	50·38	20 17 62·78	−47·60	− ·01
	α Indi	31 36·00	+ ·06	+ ·17	− ·20	− ·23	− ·03	36·23	30 48·50	·73	+ ·12
	α Delphini.....	35 58·67	+ ·03	− ·24	− ·14	− ·20	− ·02	58·50	35 10·87	·63	+ ·02
	ε Cygni........	43 08·01	+ ·03	− ·36	− ·16	+ ·14	− ·03	07·63	42 20·09	·54	·07
	θ Capricorni....	21 01 20·73	+ ·05	− ·06	− ·14	− ·01	− ·02	20·55	21 00 33·03	·52	− ·09
	ν Aquarii......	05 09·73	+ ·04	− ·10	− ·14	− ·04	− ·02	09·47	04 21·88	·59	− ·02
W	γ Pavonis	19 17·62	− ·07	+ ·50	+ ·33	·15	− ·05	18·18	18 30·67	·51	− ·10
	ζ Capricorni ...	21 58·97	− ·04	− ·03	+ ·15	·17	− ·02	58·86	21 11·23	·63	+ ·02
	β Aquarii......	27 18·34	− ·03	− ·12	+ ·14	·21	− ·02	18·10	26 30·46	·64	+ ·03
	ξ Aquarii.....	33 26·67	− ·04	− ·12	+ ·14	·27	− ·02	26·34	32 38·65	·69	+ ·08
	ε Pegasi......	40 16·71	− ·03	− ·21	+ ·14	·32	− ·02	16·27	39 28·59	·68	+ ·07
	δ Capricorni	42 32·67	− ·04	− ·07	+ ·14	− ·34	− ·02	32·32	41 44·68	·64	+ ·03

$a = -{}^s\cdot340 \quad c = -{}^s\cdot136$

Chronometer correction at $21^h\ 00^m = -47^s\cdot615 \pm {}^s\cdot015$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	σ Aquarii.......	22 26 22·71	·04	·13	+ ·11	− ·37	− ·02	23·00	22 25 34·32	−48·68	·00
	η Aquarii.......	31 14·31	− ·04	·20	+ ·11	·33	− ·02	14·49	30 25·79	·70	+ ·02
	β Gruis	37 44·63	− ·06	+ ·22	+ ·16	+ ·28	− ·03	45·20	36 56·47	·73	+ ·05
	η Pegasi	39 19·82	·03	·43	+ ·12	+ ·26	− ·02	19·72	38 30·99	·73	+ ·05
	ε Gruis	43 33·77	− ·06	+ ·29	+ ·17	+ ·24	− ·03	34·38	42 45·78	·60	·08
	α Pegasi......	23 00 48·17	− ·03	− ·31	+ ·11	+ ·09	− ·02	48·01	59 59·36	·65	− ·03
E	γ Toucani	12 38·54	+ ·33	− ·43	− ·21	− ·01	− ·04	39·04	23 11 50·29	·75	+ ·07
	κ Piscium.......	22 50·12	+ ·17	− ·21	·11	·09	− ·02	49·86	22 01·19	·67	− ·01
	ι Piscium......	35 50·35	+ ·17	·24	− ·11	·20	− ·02	49·95	35 01·30	·65	·03
	δ Sculptoris.....	44 44·81	− ·21	·00	− ·12	− ·27	− ·02	44·61	43 56·01	·60	− ·08
	φ Pegasi......	48 26·31	− ·14	·34	·11	·30	− ·02	25·68	47 36·98	·70	− ·02
	ω Piscium ..	55 12·71	+ ·16	·25	− ·11	·37	− ·02	12·12	54 23·48	·64	− ·04

$a = +{}^s\cdot439 \quad c = -{}^s\cdot108$

Chronometer correction at $23^h\ 11^m = -48^s\cdot676 \pm {}^s\cdot012$

TRANSIT OBSERVATIONS.

Station : SOUTHPORT. Date, October 6th, 1903. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·40	s.		h. m. s.	m. s.	s.
E	θ Aquilæ	20 07 40·87	·00	− ·15	− ·10	+ ·19	− ·02	40 79	20 06 20·84	−1 19·95	+ ·01
	α² Capricorni	14 03·39	·00	− ·09	− ·10	+ ·15	− ·02	03·33	12 43·40	·93	·01
	β Capricorni	16 56·69	·00	− ·08	− ·10	+ 13	− ·02	56·62	15 36 76	·86	·08
	α Pavonis ...	19 22·45	·00	+ ·29	− ·18	+ ·11	− ·04	22·63	18 02·69	·94	·00
	ρ Capricorni	24 42·83	·00	− ·06	− ·10	+ ·08	· ·02	42 73	23 22·83	·90	04
	ε Delphini	29 57·81	·00	− ·21	− ·10	+ ·05	− ·02	57·53	28 37·58	·95	+ ·01
	α Indi	32 08 42	·00	+ ·16	− ·15	+ ·03	− ·03	08 43	30 48 43	20·00	+ ·06
W	β Pavonis	37 37·79	·39	+ ·51	+ ·25	01	− ·05	38 10	36 18·20	19·90	·04
	ε Cygni	43 40 39	· ·11	− ·35	+ ·12	05	− ·02	39·98	42 20·03	·95	+ ·01
	α Aquarii	48 48·79	·19	− ·11	+ ·10	·08	− ·02	48·49	47 28·45	20·04	+ 10
	32 Vulpeculæ	51 48·85	− ·13	− ·31	+ ·11	·10	− ·02	48·40	50 28·48	19·92	·02
	1 Piscis Aust. ...	56 44 26	− ·24	+ ·03	+ ·12	·13	·02	44·02	55 24 04	·98	+ ·04
	θ Capricorni	21 01 53·22	− ·21	− ·06	+ ·10	·17	− ·02	52·86	21 00 32·99	·87	·07
	ν Aquarii	05 42 22	− ·20	− ·09	+ ·10	·19	− ·02	41 82	04 21·84	·98	+ ·04

$a = +^{s}\cdot330$ $c = -^{s}\cdot099$

Chronometer correction at $20^{h}\ 36^{m} = -1^{m}\ 19^{s}\cdot942 \pm {}^{s}\cdot010$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	α Piscis Aust ...	22 53 42·04	·13	+ ·01	+ ·10	+ ·29	− ·02	42·29	22 52 21·09	−1 21·20	+ ·05
	α Pegasi	23 01 20·47	·09	·25	+ ·09	− ·24	− ·02	20·44	59 59·34	·10	− ·05
	γ Toucani	13 10·97	19	+ ·35	+ ·16	+ ·16	− ·04	11·41	23 11 50 26	·15	·00
	τ Pegasi	17 15·16	· ·08	·30	+ ·09	+ ·13	− ·02	14 98	15 53·90	·08	·07
	κ Piscium	23 22·42	·10	· ·17	+ ·08	+ ·09	− ·02	22·30	22 01·18	12	− ·03
	ι Phœnicis	31 16·22	· ·15	+ ·13	− ·11	+ ·04	− ·03	16·32	29 55·11	·21	+ ·06
	ι Piscium	36 22·62	·10	− ·20	· ·08	+ ·01	− ·02	22·39	35 01·29	·10	− ·05
E	δ Sculptoris	45 17·12	+ ·14	00	· 09	− ·05	− ·02	17·10	43 56·00	·10	− ·05
	ω Piscium	55 44·98	+ 10	− ·20	− ·08	− ·12	− ·02	44·66	54 23·50	·16	+ ·01
	2 Ceti	24 00 11·16	· ·13	·06	·09	· ·15	− ·02	10·97	58 49 80	·17	+ ·02
	α Andromedæ ..	04 48·23	+ ·08	− 34	· ·09	·18	·02	47·68	24 03 26·45	·23	+ ·08
	γ Pegasi	09 39·86	+ ·09	− ·25	·09	− ·21	− ·02	39·38	08 18·24	·14	− ·01
	ι Ceti	15 54·21	+ ·12	− ·11	− ·08	− ·25	− ·02	53·87	14 32·69	·18	+ ·03
	β Hydri	22 05·68	+ ·37	+1·28	·39	− ·29	− ·09	06·56	20 45·43	·13	· ·02

$a = +^{s}\cdot355$ $c = -^{s}\cdot083$

Chronometer correction at $23^{h}\ 37^{m} = -1^{m}\ 21^{s}\cdot148 \pm {}^{s}\cdot009$

TRANSIT OBSERVATIONS.

Station : SOUTHPORT. Date, October 7th, 1903. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·35	s.		h. m. s.	m. s.	s.
E	ξ Aquarii......	21 34 09·63	+ ·17	− ·13	− ·08	+ ·26	− ·02	09·83	21 32 38·60	-1 31·23	+ ·02
	ϵ Pegasi........	40 59·74	+ ·14	− ·23	− ·08	+ ·22	− ·02	59·77	39 28·54	·23	+ ·02
	δ Capricorni....	43 15·61	+ ·18	− ·08	− ·08	+ ·20	− ·02	15·81	41 44·63	·18	− ·03
	γ Gruis	49 37·87	+ ·22	+ ·08	− ·10	+ ·17	− ·03	38·21	48 06·97	·24	+ ·03
	α Aquarii......	22 02 22 71	+ ·16	− ·17	− ·08	+ ·09	− ·02	22·69	22 00 51·45	·24	+ ·03
	ι Pegasi...... .	04 04·52	+ ·12	− ·33	− ·08	+ ·08	− ·02	04·29	02 33·14	15	− ·06
W	η Pegasi.......	40 02·65	− ·07	− ·36	+ ·09	− ·13	− ·02	02·16	38 30·96	·20	− ·01
	ϵ Gruis	44 16·85	− ·16	+ ·24	+ ·12	·15	− ·03	16·87	42 45·72	·15	·06
	μ Pegasi.... ..	46 54·66	− ·07	− ·32	+ ·08	·16	− ·02	54·17	45 22·90	·27	+ ·06
	λ Aquarii.... ..	49 08·27	− ·10	− ·13	+ ·08	− ·18	− ·02	07·92	47 36·74	·18	− ·03
	δ Aquarii.......	51 05·19	− ·11	− ·08	+ ·08	19	− ·02	04·87	49 33·65	·22	+ ·01
	α Piscis Aust...	53 52·60	− ·13	+ ·01	+ ·09	− ·20	− ·02	52·35	52 21·08	·27	+ ·06
	α Pegasi.......	23 01 31·07	− ·08	− ·26	+ ·08	− ·26	− ·02	30·53	59 59·31	·19	− ·02

$a = + {}^{s}\cdot372$ $c = - {}^{s}\cdot077$

Chronometer correction at 22^{h} $18^{m} = -1^{m}$ $31^{s}\cdot215 \pm {}^{s}\cdot010$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	δ Sculptoris	23 45 27·83	·16	·00	+ ·18	+ ·20	− ·02	28 03	23 43 55·95	−1 32·08	+ ·08
	φ Pegasi........	49 09·09	·10	− ·35	+ 16	+ ·17	− ·02	08·95	47 36·98	31·97	− ·03
	ω Piscium	55 55·63	·11	·26	+ ·16	+ ·14	− ·02	55·54	54 23·50	32·04	+ ·04
	2 Ceti..........	24 00 21·82	·14	− ·08	+ ·16	+ ·11	− ·02	21·85	58 49·80	32·05	+ ·05
	α Andromedæ ..	04 58 68	·08	43	+ ·18	+ ·09	− ·02	58·42	24 03 26 45	31·97	− ·03
	γ Pegasi.. . . .	09 50·42	·10	·32	+ ·16	+ ·06	− ·02	50·20	08 18·25	31·95	− ·05
	ζ Toucani	16 36·79	27	+ ·66	+ ·37	+ ·02	− ·05	37·52	15 05 55	31·97	·03
E	β Hydri........	22 16·05	+ ·58	+ 1·64	·73	·02	− ·09	17·43	20 45·42	32·01	+ ·01
	12Ceti...... ...	26 41·17	+ ·17	·18	− ·15	·04	− ·02	40·95	25 08·93	32·02	+ ·02
	ϵ Andromedæ ..	35 02·37	+ ·12	− ·43	− ·18	·09	− ·02	01 77	33 29·89	31·88	− ·12
	β Ceti	40 18·97	+ ·20	− ·08	− ·16	− ·12	− ·02	18·79	38 46·76	32·03	+ ·03
	δ Piscium	45 15 23	+ ·14	·26	·16	·15	− ·02	14·78	43 42·70	32 08	+ ·08
	20Ceti..	49 39·09	+ ·17	− ·20	·15	·18	− ·02	38·71	48 06·65	32 06	+ ·06
	μ Andromedæ ..	52 59 45	+ 10	·52	− ·20	·20	− ·03	58·60	51 26·63	31·97	·03

$a = - {}^{s}\cdot455$ $c = - {}^{s}\cdot155$

Chronometer correction at 24^{h} $19^{m} = -1^{m}$ $32^{s}\cdot005 \pm {}^{s}\cdot012$

TRANSIT OBSERVATIONS.

Station : SOUTHPORT. Date, October 8th, 1903. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·50	s.		h. m. s.	m. s.	s.
E	β Pavonis	20 37 59·55	+ ·27	+ ·59	− ·27	+ ·35	− ·05	60·44	20 36 18·11	−1 42·33	+ ·03
	ε Cygni...	44 02·43	+ ·08	− ·40	− ·13	+ ·30	− ·02	02·26	42 19·99	·27	− ·03
	μ Aquarii......	49 10·58	+ ·13	− ·12	− ·11	+ ·26	− ·02	10·72	47 28·42	·30	·00
	32 Vulpeculæ....	52 10·88	+ ·09	− ·35	− ·12	+ ·23	− ·02	10·71	50 28·44	·27	− ·03
	ι Piscis Aust....	57 06·03	+ ·16	+ ·04	− ·13	+ ·19	− ·02	06·27	55 24·01	·26	− ·04
	θ Capricorni....	21 02 15·16	+ ·15	− ·07	− ·11	+ ·15	− ·02	15·26	21 00 32·96	·30	·00
	ν Aquarii	06 04·07	+ ·14	− ·11	− ·11	+ ·12	− ·02	04·09	04 21·81	·28	− ·02
W	γ Pavonis	20 12·25	− ·31	+ ·57	+ ·26	·00	− ·05	12·72	18 30·49	·23	·07
	ζ Capricorni....	22 53·66	− ·17	− ·04	+ ·12	− ·02	− ·02	53·53	21 11·19	·34	+ ·04
	β Aquarii	28 12·99	− ·15	− ·14	+ ·11	− ·07	− ·02	12·72	26 30·40	·32	+ ·02
	ξ Aquarii	34 21·17	− ·15	− ·13	+ ·11	− ·12	− ·02	20·86	32 38·58	·28	− ·02
	ε Pegasi	41 11·28	− ·13	− ·24	+ ·11	− ·17	− ·02	10·83	39 28·53	·30	·00
	γ Gruis.........	49 49·57	·20	+ ·08	+ ·13	− ·24	− ·03	49·31	48 06·96	·35	+ ·05
	α Aquarii	22 02 34·32	− ·14	− ·17	+ ·11	− ·35	− ·02	33·75	22 00 51·44	·31	+ ·01

$a = +^{s}\cdot380$ $c = -^{s}\cdot106$

Chronometer correction at $21^h\ 20^m = -1^m\ 42^s\cdot296 \pm {}^s\cdot007$

W	α Toucani	22 13 38·20	− ·21	+ ·44	+ ·22	+ ·49	− ·04	39·10	22 11 55·80	−1 43·30	+ ·08
	η Pegasi	40 14·24	− ·07	·38	+ ·13	+ ·27	− ·02	14·17	38 30·95	·22	·00
	μ Pegasi	47 06·21	− ·08	− ·34	+ ·12	+ ·21	− ·02	06·10	45 22·90	·20	− ·02
	λ Aquarii.......	49 19·92	− ·11	·13	+ ·11	+ ·19	− ·02	19·96	47 36·73	·23	+ ·01
	δ Aquarii.......	51 16·81	− ·12	·08	+ ·11	+ ·17	− ·02	16·87	49 33·64	·23	+ ·01
	α Piscis Aust...	54 04·21	− ·14	+ ·02	+ ·13	+ ·15	− ·02	04·35	52 21·07	·28	+ ·06
	α Pegasi..... ..	23 01 42·76	− ·09	− ·27	+ ·11	+ ·09	− ·02	42·58	59 59·33	·25	+ ·03
E	γ Toucani	13 32·90	+ ·35	+ ·39	− ·21	− ·01	− ·04	33·38	23 11 50·24	·14	− ·08
	ι Piscium	36 44·91	+ ·17	·22	− ·11	− ·20	− ·02	44·53	34 61·29	·24	+ ·02
	φ Pegasi	49 20·83	+ ·16	− ·30	− ·11	− ·31	− ·02	20·25	47 36·98	·27	+ ·05
	ω Piscium ...	56 07·27	+ ·17	− ·22	·11	·37	− ·02	06·72	54 23·49	·23	+ ·01
	2 Ceti..........	24 00 33·35	+ ·22	− ·07	− ·11	− ·40	− ·02	32·97	58 49·80	·17	·05
	α Andromedæ ..	05 10·47	+ ·13	− ·37	− ·12	− ·44	− ·02	09·65	24 03 26·45	·20	− ·02
	γ Pegasi........	10 02·13	+ ·16	− ·27	− ·11	− ·49	− ·02	01·40	08 18·25	·15	− ·07

$a = +^{s}\cdot392$ $c = -^{s}\cdot109$

Chronometer correction at $23^h\ 12^m = -1^m\ 43^s\cdot219 \pm {}^s\cdot010$

TRANSIT OBSERVATIONS.

Station: SOUTHPORT. Date, October 9th, 1903. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·48	s.		h. m. s.	m. s.	s.
E	β Pavonis . .	20 38 11·49	− ·31	+ ·60	− ·27	+ ·29	− ·05	12·37	20 36 18·09	−1 54·28	+ ·06
	ε Cygni.	45 14·40	·09	·40	13	+ ·23	− ·02	14·17	42 19·97	·20	·02
	μ Aquarii	49 22·51	+ ·15	− ·12	− ·11	+ ·20	− ·02	22·61	47 28·41	·20	− ·02
	32 Vulpeculæ	52 22·86	− ·10	·36	− ·12	+ ·18	− ·02	22·64	50 28·42	22	·00
	ι Piscis Aust. . .	57 17·94	19	+ ·04	·13	+ ·14	− ·02	18·16	55 23·99	·17	− ·05
	θ Capricorni. . . .	21 02 27·04	+ 16	− 07	− 12	+ 10	− ·02	27·09	21 00 32·94	·15	− ·07
	ν Aquarii.	06 16·06	+ 16	− ·11	− ·11	+ ·06	− ·02	16·04	04 21·79	·25	+ ·03
W	γ Pavonis	20 24·15	·31	+ ·58	− ·27	− ·05	− ·05	24·59	18 30·45	·14	·08
	ζ Capricorni. . . .	23 05·57	− 17	− 04	+ 12	− ·07	− ·02	05·39	21 11·15	·24	− ·02
	β Aquarii.	28 24·88	− ·15	·15	+ ·11	− ·11	− ·02	24·56	26 30·39	·17	·05
	ξ Aquarii.	34 33·24	− ·15	− ·13	+ ·11	·16	− ·02	32·89	32 38·57	32	+ ·10
	ε Pegasi.	41 23·25	·13	− 24	+ ·11	− ·22	− ·02	22·75	39 28·52	·23	+ ·01
	δ Capricorni. . . .	43 39·21	·16	− ·08	− 11	− ·23	− ·02	38·83	41 44·60	·23	− ·01
	γ Gruis	50 01·50	20	+ ·08	+ ·14	·29	− ·03	01·20	48 06·95	·25	·03

$a = +^{s}\cdot386$ $c = -^{s}\cdot110$

Chronometer correction at $21^{h}\ 14^{m} = -1^{m}\ 54^{s}\cdot217 \pm {}^{s}\cdot009$

TRANSIT OBSERVATIONS.

Station: SOUTHPORT. Date, October 10th, 1903. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·50	s.		h. m. s.	m. s.	s.
E	β Pavonis	20 38 23·42	+ ·30	+ ·56	− ·36	− ·30	− ·05	24·17	20 36 18·06	−2 06·11	+ ·01
	ε Cygni	44 26·29	+ ·09	− ·38	− ·17	− ·25	− ·02	26·06	42 19·95	·11	+ ·01
	μ Aquarii .	49 34·43	+ ·15	− ·12	− ·14	+ ·21	− ·02	34·51	47 28·40	·11	+ ·01
	32 Vulpeculæ. . . .	52 34·75	+ ·10	− ·34	− ·16	+ ·18	− ·02	34·51	50 28·40	·11	+ ·01
	ι Piscis Aust. . .	57 29·90	+ ·18	+ ·04	− ·16	+ ·14	− ·02	30·08	55 23·97	·11	+ ·01
	θ Capricorni. . . .	21 02 38·95	+ ·16	− ·07	− ·14	+ ·10	− ·02	38·98	21 00 32·93	·05	− ·05
	ν Aquarii	06 27·92	+ ·15	− ·10	− ·14	+ 06	− ·02	27·87	04 21·78	·09	− ·01
W	γ Pavonis	20 35·98	− ·27	+ ·54	− ·34	− ·05	− ·05	36·49	18 30·41	·08	·02
	ζ Capricorni. . . .	23 17·36	− ·15	− ·04	+ ·15	− ·07	− ·02	17·23	21 11·14	·09	− ·01
	β Aquarii. .	28 36·73	− ·13	− ·14	+ ·14	− ·12	− ·02	36·46	26 30·38	·08	− ·02
	ξ Aquarii	34 44·96	− ·13	− ·12	+ ·14	− ·17	− ·02	44·66	32 38·56	·10	·00
	ε Pegasi.	41 35·07	− ·11	− ·22	+ ·14	− ·23	− ·02	34·63	39 28·50	·13	+ ·03
	δ Capricorni. . . .	43 51·01	− ·14	− ·08	+ ·14	− ·24	− ·02	50·67	41 44·59	·08	− ·02
	γ Gruis.	50 13·34	− ·17	+ ·08	+ ·18	− ·30	− ·03	13·10	48 06·93	·17	+ ·07

$a = +^{s}\cdot362$ $c = -^{s}\cdot138$

Chronometer correction at $21^{h}\ 14^{m} = -2^{m}\ 06^{s}\cdot102 \pm {}^{s}\cdot005$

TRANSIT OBSERVATIONS.

Station: SOUTHPORT. Date, October 11th, 1903. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r= · ·44	s		h. m. s.	m. s.	s.
E	ρ Capricorni....	20 25 39·44	+ ·09	− ·06	− ·11	+ ·23	− ·02	39·57	20 23 22·74	-2 16·83	+ ·04
	ε Delphini......	30 54·39	+ ·07	− ·23	− ·11	+ ·19	·02	54·29	28 37·50	79	·00
	β Pavonis.......	38 34·26	+ ·16	+ ·56	− ·27	+ ·14	− ·05	34·80	36 18·00	·80	01
	ε Cygni.......	44 37·09	+ ·05	− ·38	− ·13	+ ·10	− ·02	36·71	42 19·92	·79	·00
	μ Aquarii	49 45·26	+ ·08	− ·11	− ·11	+ ·06	− ·02	45·16	47 28·38	·78	·01
	32 Vulpeculæ....	52 45·50	+ ·05	− ·33	− ·12	+ ·04	− ·02	45·12	50 28·38	·74	− ·05
	ι Piscis Aust...	57 40·73	+ ·10	+ ·04	− ·13	·00	− ·02	40·72	55 23·95	·77	·02
W	θ Capricorni...	21 02 49·83	− ·16	− ·06	+ ·11	− ·04	− ·02	49·66	21 00 32·91	·75	·04
	ν Aquarii.......	06 38·83	− ·16	− ·10	+ ·11	·06	− ·02	38·60	04 21·76	·84	+ 05
	ζ Cygni	11 08·70	− ·10	− ·35	+ ·12	11	− ·02	08·24	08 51·44	·80	+ ·01
	α Equulei....	13 18·72	− ·13	− ·19	+ ·11	·11	− ·02	18·38	11 01·58	·80	+ ·01
	γ Pavonis.	20 46·87	− ·31	+ ·54	+ ·26	− ·16	·05	47·15	18 30·37	·78	− ·01
	ζ Capricorni.....	23 28·23	− ·17	− ·04	+ ·12	− ·19	·02	27·93	21 11·12	·81	+ ·02
	β Aquarii.......	28 47·57	− ·15	− ·14	+ ·11	·23	− ·02	47·14	26 30·36	·78	− ·01

$a = +^{s}\cdot357$ $c = {}^{s}\cdot106$

Chronometer correction at $20^{h}\ 57^{m} = -2^{m}\ 16^{s}\cdot789 \pm {}^{s}\cdot005$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	ε Pegasi........	21 41 45·86	− ·13	− ·19	+ ·09	+ ·34	− ·02	45 95	21 39 28·49	-2 17·46	− ·01
	δ Capricorni....	44 01·87	·16	·06	+ ·10	+ ·32	− ·02	02·05	41 44 58	·47	·00
	γ Gruis	50 24·17	·19	+ ·07	+ ·12	+ ·28	− ·03	24·42	48 06·91	·51	+ ·04
	α Aquarii	22 03 08·91	·14	− ·14	+ ·09	+ ·19	− ·02	08·89	22 00 51·41	·48	+ ·01
	ι Pegasi.	04 50·62	− ·10	− ·26	+ ·10	+ ·17	− ·02	50·51	02 33·09	·42	·05
	α Toucani......	14 12·86	− ·26	+ ·33	+ ·19	+ ·10	− ·04	13·18	11 55·72	·46	·01
E	ε Gruis	45 03·04	+ ·17	+ ·19	− ·15	− ·13	− ·03	03·09	42 45·64	·45	− ·02
	δ Aquarii.......	51 51 28	+ ·12	− 06	− ·10	− ·16	− ·02	51·06	49 33·62	·44	− ·03
	α Piscis Aust...	54 38·68	+ ·13	− ·01	− 11	·18	− ·02	38·51	52 21·04	·47	·00
	α Pegasi........	23 02 17·29	+ ·08	− ·21	− ·10	− ·25	− ·02	16·79	59 59·31	·48	+ ·01
	c² Aquarii... ...	06 37·78	+ ·12	− ·04	− ·10	− ·27	− ·02	37·47	23 04 20·01	·46	− ·01
	γ Toucani....	14 07·73	+ ·19	+ ·30	− ·18	− ·34	− ·04	07·66	11 50·18	·48	+ ·01

$a = +^{s}\cdot298$ $c = -^{s}\cdot093.$

Chronometer correction at $22^{h}28^{m} = -2^{m}17^{s}\cdot466 \pm {}^{s}\cdot005$

TRANSIT OBSERVATIONS.

Station : SOUTHPORT. Date, October 12th, 1903. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	r.
		h. m. s.	s.	s.	s.	s. r = − ·36	s.		h. m. s.	m. s.	s.
E	β Pavonis.......	20 38 46·06	+ ·06	+ ·55	− ·22	+ ·19	− ·05	46·59	20 36 17·96	−2 28·63	+ ·06
	ε Cygni........	44 48·72	+ ·02	·37	− ·10	+ ·16	− ·02	48·41	42 19·90	·51	− ·06
	μ Aquarii . .	49 56·98	+ ·03	− 11	·09	+ ·12	− ·02	56·91	47 28·36	·55	− ·02
	32 Vulpeculæ....	52 57·17	+ ·02	− ·33	− ·10	+ ·11	− ·02	56·85	50 28·36	·49	·08
	ι Piscis Aust...	57 52·49	+ ·04	+ ·04	·10	+ ·08	− ·02	52·53	55 23·93	·60	+ ·03
	θ Capricorni....	21 03 01·50	+ ·03	− ·07	− ·09	+ ·04	− ·02	01·39	21 00 32 89	·50	− ·07
	ν Aquarii... ...	06 50·48	+ ·03	− ·10	·09	+ ·02	− ·02	50·32	04 21·75	·57	·00
W	ζ Cygni........	11 20·46	− ·11	− ·34	+ ·10	− ·01	− ·02	20·08	08 51·42	·66	+ ·09
	α Equulei......	13 30·46	− ·16	− ·19	+ 09	·02	− ·02	30·16	11 01·55	·61	− ·04
	γ Pavonis......	20 58·53	− ·37	+ ·53	+ ·21	− ·06	− ·05	58·79	18 30·33	·46	− ·11
	ζ Capricorni....	23 39·92	− ·20	·04	+ ·09	·08	− ·02	39·67	21 11·10	·57	·00
	β Aquarii.......	28 59·27	− ·17	− ·13	+ ·09	− ·11	− ·02	58·93	26 30·35	·58	− ·01
	ξ Aquarii.......	35 07·53	− ·18	− ·13	+ ·09	·15	− ·02	07·14	32 38·53	·61	+ ·04
	ε Pegasi	41 57·56	− ·15	− ·22	+ 09	·19	− ·02	57·07	39 28·48	·59	− 02

$a = -^s{\cdot}354 \qquad c = -^s{\cdot}086$

Chronometer correction at $21^h\ 10^m = -2^m\ 28^s{\cdot}565 \pm ^s{\cdot}012$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	r.
W	δ Capricorni....	21 44 13·52	− ·16	− ·06	+ ·06	+ ·25	− ·02	13·59	21 41 44·56	−2 29·03	·02
	γ Gruis	50 35·89	− ·19	+ ·06	+ ·08	+ ·21	− ·03	36 02	48 06·89	·13	+ ·08
	α Aquarii	22 03 20·55	− ·14	− ·13	+ 06	+ ·13	− ·02	20·45	22 00 51·40	·05	·00
	ι Pegasi........	05 02·31	− ·10	− ·24	+ ·07	+ 12	− ·02	02·14	02 33·07	·07	+ ·02
	α Toucani......	14 24·51	− ·27	+ ·31	+ ·13	+ ·07	− ·04	24·71	11 55·69	·02	− ·03
	γ Aquarii	19 11·36	− ·14	·12	+ 06	+ ·04	− ·02	11 18	16 42 13	·05	·00
E	μ Pegasi	47 52·35	+ ·08	− ·24	− ·07	·13	− ·02	51·97	45 22·86	·11	+ ·06
	λ Aquarii	50 05·92	+ ·11	·09	·06	− 15	− ·02	05·71	47 36·70	·01	− ·04
	δ Aquarii	52 02·88	+ 12	− ·06	·06	·16	− ·02	02·70	49 33·61	·09	+ ·04
	α Piscis Aust...	54 50·16	+ ·14	− ·01	− ·07	− ·17	− ·02	50·05	52 21 03	·02	− ·03
	c^2 Aquarii	23 06 49·20	+ ·12	− ·03	− ·07	·25	− ·02	48·95	23 04 20·00	28·95	− ·10
	γ Toucani......	14 19·27	+ ·19	+ ·27	− ·12	·29	− ·04	19·28	11 50·17	29·11	+ ·06

$a = +^s{\cdot}277 \qquad c = -^s{\cdot}062$

Chronometer correction at $22^h\ 25^m = -2^m\ 29^s{\cdot}053 \pm ^s{\cdot}011$

TRANSIT OBSERVATIONS.

Station : SOUTHPORT. Date, October 13th, 1903. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·38	s.		h m. s.	m. s.	s.
E	ε Gruis	22 45 25·39	+ ·16	+ ·23	− ·04	+ ·13	− ·03	25·84	22 42 45·57	−2 40·27	+ ·04
	μ Pegasi.. ..	48 03·26	+ ·07	− ·31	·03	+ ·11	− ·02	03·08	45 22·85	·23	·00
	λ Aquarii	50 16·83	+ ·10	− ·12	− ·03	+ ·09	·02	16·85	47 36·69	·16	− ·07
	δ Aquarii	52 13·78	+ ·11	− ·07	− ·03	+ ·08	− ·02	13·85	49 33·60	25	+ ·02
	α Piscis Aust...	55 01·07	+ ·13	+ ·01	− ·03	+ ·06	− ·02	01·22	52 21·02	·20	− ·03
W	α Pegasi..	23 02 39·79	− ·08	− ·25	+ ·03	+ ·02	− ·02	39·49	59 59·29	·20	·03
	c^2 Aquarii	07 00·41	− ·12	− 04	+ ·03	·01	·02	00·25	23 04 19·99	·26	+ ·03
	γ Toucani.....	14 30·24	·19	+ ·35	+ ·05	− ·05	− ·04	30·36	11 50·15	·21	− ·02
	τ Pegasi..	18 34·58	− ·08	− ·30	+ ·03	− ·08	·02	34·13	15 53·86	·27	+ ·04
	κ Piscium......	24 41·79	− ·10	− ·17	+ ·03	− ·13	− ·02	41·40	22 01·15	·25	+ ·02

$a = +^{s}\cdot355$ $c = -^{s}\cdot025$

Chronometer correction at $23^h\ 06^m = -2^m\ 40^s\cdot229 \pm^{s}\cdot009$

TRANSIT OBSERVATIONS.

Station : SOUTHPORT. Date, October 15th, 1903. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·44	s.		h. m. s.	m. s.	s.
E	γ Gruis	21 51 10·11	+ ·04	+ ·07	− ·13	+ ·35	− ·03	10·41	21 48 06·85	−3 03·56	·00
	α Toucani	22 14 58·95	+ ·06	+ ·34	− ·21	+ ·18	− ·04	59 28	22 11 55·61	·67	+ ·11
	γ Aquarii.	19 45·73	+ ·03	− ·13	− ·10	+ 14	·02	45·65	16 42·09	·56	·00
	σ Aquarii.......	28 37·74	+ ·04	− ·09	− ·10	+ ·07	− ·02	37·64	25 34·20	·44	− ·12
	η Aquarii.......	33 29·43	+ ·03	− ·14	− ·10	·04	− ·02	29·16	30 25·68	·48	·08
W	α Piscis Aust...	55 24·76	− ·17	+ ·01	+ ·12	·13	− ·02	24·57	52 21·00	·57	+ ·01
	α Pegasi..	23 03 03·32	− ·11	− ·21	+ ·10	− ·19	− ·02	02·89	59 59·28	·61	+ ·05
	γ Toucani	14 53·65	− ·25	+ ·30	+ ·19	− ·27	− ·04	53·58	23 11 50·11	·47	− ·09
	τ Pegasi..... ..	18 57·99	·10	− ·26	+ ·11	·30	− ·02	57·42	15 53·84	·58	+ ·02
	κ Piscium	25 05·28	− ·13	− ·15	+ ·10	·35	− ·02	04·73	22 01·07	·66	+ ·10

$a = +^{s}\cdot305$ $c = -^{s}\cdot100$

Chronometer correction at $22^h\ 38^m = -3^m 03^s\cdot561 \pm^{s}\cdot019$

TRANSIT OBSERVATIONS.

Station : SOUTHPORT. Date, October 16th, 1903. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	r s. ·45	s.		h. m. s.	m. s.	s.
E	β Capricorni.. .	20 18 50·73	+ ·17	− ·09	·11	+ ·27	− ·02	50·95	20 15 36·62	-3 14·33	+ ·02
	ι Capricorni....	26 36·79	+ ·17	− ·07	·12	+ ·21	− ·02	36·96	23 22·65	·31	·00
	· Delphini. ...	31 51·78	+ ·13	− ·24	− ·11	+ ·17	− ·02	51·71	28 37·41	·30	− ·01
	β Pavonis ..	39 31·36	+ ·33	+ ·59	− ·28	+ ·12	− ·05	32·07	36 17·73	·34	+ ·03
	ε Cygni	45 34·45	+ ·09	− ·40	− ·13	+ ·07	− ·02	34·06	42 19·82	·24	− ·07
	μ Aquarii. ...	50 42·68	+ ·16	− ·12	− ·11	+ ·03	− ·02	42·62	47 28·30	·32	+ ·01
	32 Vulpeculæ....	53 42·92	+ ·11	− ·35	− ·12	+ ·01	− ·02	42·55	50 28·29	·26	− ·05
W	θ Capricorni....	21 03 47·37	− ·16	− ·07	+ ·12	·07	− ·02	47·17	21 00 32·83	·34	− ·03
	ν Aquarii... .	07 36·32	− ·16	− ·11	+ ·11	·10	− ·02	36·04	04 21·69	·35	− ·04
	ζ Cygni	12 06·15	− ·10	− ·37	+ ·13	·14	− ·02	05·65	08 51·34	·31	·00
	α Equulei	14 16·28	− ·13	·21	+ ·11	·15	− ·02	15·88	10 61·51	·37	+ ·06
	γ Pavonis	21 44·11	− ·31	+ ·57	+ ·27	·20	− ·05	44·39	18 30·16	·23	·08
	ζ Capricorni ..	24 25·71	− ·17	− ·04	+ ·12	·23	− ·02	25·37	21 11·04	·33	+ ·02
	β Aquarii....	29 45·10	− ·15	− ·14	+ ·11	·27	·02	44·63	26 30·29	·34	+ ·03

a ·3·1 c − ·110

Chronometer correction at $20^h\ 54^m = -3^m\ 14^s{\cdot}311 \pm {}^s{\cdot}009$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	ξ Aquarii.......	21 35 53·26	·16	− ·13	+ ·13	+ ·49	− ·02	53·57	21 32 38·47	-3 15·10	− ·02
	ε Pegasi...... ..	42 43·41	·13	·24	+ ·13	+ ·45	− ·02	43·60	39 28·42	·18	+ ·06
	δ Capricorni....	44 59·31	·17	·08	+ ·13	+ ·43	− ·02	59·60	41 44·50	·10	− ·02
	γ Gruis	51 21·62	− ·21	+ ·09	+ ·16	+ ·38	− ·03	22·01	48 06·84	·17	+ ·05
	α Aquarii.	22 04 06·36	·15	− ·18	+ ·13	+ ·28	− ·02	06·42	22 00 51·35	·07	− ·05
	ι Pegasi	05 48·17	− ·11	·34	+ ·14	+ ·27	− ·02	48·11	02 33·01	·10	− ·02
	α Toucani	15 10·15	·29	·43	+ ·26	+ ·20	− ·04	10·71	11 55·58	·13	+ ·01
E	ψ² Aquarii.......	23 07 35·20	+ ·23	·05	·14	·20	− ·02	35·02	23 04 19·97	·05	− ·07
	γ Toucani	15 05·02	+ ·36	+ ·38	− ·24	·25	− ·04	05·23	11 50·10	·13	+ ·01
	τ Pegasi........	19 09·63	+ ·15	− ·33	− ·13	·28	− ·02	09·02	15 53·84	·18	+ ·06
	κ Piscium	25 16·71	+ ·19	·19	·13	− ·33	− ·02	16·23	21 61·13	·10	− ·02
	ι Phœnicis	33 10·32	+ ·28	+ ·14	− ·17	·39	− ·03	10·15	29 55·03	·12	·00
	ι Piscium	38 17·02	+ ·18	− ·21	− ·13	·42	− ·02	16·42	35 01·26	·16	+ ·04
	δ Sculptoris	47 11·45	+ ·25	·00	·14	− ·49	− ·02	11·05	43 55·96	·09	− ·03

$a = - {}^s{\cdot}388$ $c = - {}^s{\cdot}126$

Chronometer correction at $22^h\ 41^m = -3^m\ 15^s{\cdot}119 \pm {}^s{\cdot}008$

The following observations at Sydney, together with their reduction and clock corrections have been furnished by Mr. H. A. Lenehan, Acting Government Astronomer. The method of determining the level, azimuth and collimation errors there, has already been given under 'Sydney Observatory.'

TRANSIT OBSERVATIONS.

Station: SYDNEY. Date, September 29th, 1903. Observer: H. A. LENEHAN.

Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Rate.	Seconds of corr. transit.	R. A.	Chronometer correction.
	h. m. s.	s.	s.			h. m. s.	s.
ε Delphini	20 28 21·92	+·01	+2·46	Losing 1s·00 every 24 hours.	24·39	20 28 37·69	+13·30
α Indi	20 30 36·64	+·02	-1·18		35·48	20 30 48·60	13·12
ε Aquarii	20 42 13·98	+·01	+1·39		15·38	20 42 28·73	13·35
μ Aquarii	20 47 13·78	+·01	+1·44		15·23	20 47 28·56	13·33
32 Vulpeculæ	20 50 11·80	+·01	-3·39		15·20	20 50 28·60	13·40
ι Piscis Aust.	20 55 10·67	+·02	+0·09		10·78	20 55 24·16	13·38
						Mean	13·31

Chronometer correction at $20^h 42^m = +13^s{\cdot}31$

TRANSIT OBSERVATIONS.

Station: SYDNEY. Date, October 2nd, 1903. Observer: W. E. RAYMOND.

Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Rate.	Seconds of corr. transit.	R. A.	Chronometer correction.
	h. m. s.	s.	s.			h. m. s.	s.
β Capricorni	20 15 18·88	-·01	+1·14	Losing 1s·30 every 24 hours.	20·01	20 15 36·83	+16·82
α Pavonis	20 17 48·67	·02	-2·53		46·12	20 17 62·81	16·69
ε Delphini	20 28 18·21	·01	+2·48		20·68	20 28 37·64	16·96
α Indi	20 30 33·09	·02	-1·19		31·88	20 30 48·52	16·64
α Delphini	20 34 51·19	-·01	+2·74		53·92	20 35 10·89	16·97
ε Aquarii	20 42 10·41	·01	+1·39		11·79	20 42 28·68	16·89
μ Aquarii	20 47 10·25	-·01	+1·44		11·68	20 47 28·51	16·83
θ Capricorni	21 00 15·09	-·01	+0·98		16·06	21 00 33·04	16·98
γ Pavonis	21 18 18·40	·03	4·44		13·93	21 18 30·70	16·77
β Aquarii	21 26 11·96	-·01	+1·60		13·55	21 26 30·47	16·92
						Mean	16·85

Chronometer correction at $20^h 44^m = +16^s{\cdot}85$

TRANSIT OBSERVATIONS.

Station: SYDNEY. Date, October 3rd, 1903. Observer: W. E. RAYMOND.

Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Rate.	Seconds of corr. transit.	R. A.	Chronometer correction.
	h. m. s.	s.	s.			h. m. s.	s.
μ Aquarii	20 47 08·68	− ·04	+1·46	Losing 1s·60 every 24 hours.	10·10	20 47 28·50	+18·40
32 Vulpeculæ	20 50 06·57	− ·03	+3·43		9·97	20 50 28·53	18·56
ι Piscis Aust.	20 55 05·55	·06	+0·09		5·58	20 55 24·09	18·51
θ Capricorni	21 00 13·61	− ·05	+0·99		14·55	21 00 33·02	18·47
ι Capricorni	21 16 34·64	− ·05	+1·04		35·63	21 16 54·11	18·48
γ Pavonis	21 18 16·87	·10	−4·47		12·30	21 18 30·67	18·37
ζ Capricorni	21 20 52·09	− ·05	+0·73		52·77	21 21 11·24	18·47
β Aquarii	21 26 10·41	− ·04	+1·61		11·98	21 26 30·46	18·48
ξ Aquarii	21 32 18·72	·04	+1·51		20·19	21 32 38·64	18·45
ε Pegasi	21 39 07·66	·04	+2·39		10·01	21 39 28·59	18·58
δ Capricorni	21 41 25·18	− ·05	+1·04		26·17	21 41 44·66	18·49
γ Gruis	21 47 48·85	·06	−0·31		48·48	21 48 07·04	18·56
						Mean	18·49

Chronometer correction at $21^h\ 21^m = +18^s{\cdot}49$

TRANSIT OBSERVATIONS.

Station: SYDNEY. Date, October 6th, 1903. Observer: H. A. LENEHAN.

Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Rate.	Seconds of corr. transit.	R. A.	Chronometer correction.
	h. m. s.	s.	s.			h. m. s.	s.
β¹ Scorpii	15 59 27·08	− ·08	+0·88	Losing 1s·18 per day.	27·88	15 59 49·61	+21·73
δ Ophiuchi	16 08 53·81	− ·06	+1·75		55·50	16 09 17·34	21·84
α Scorpii	16 23 07·43	− ·08	+0·52		7·87	16 23 29·66	21·79
α Triang. Aust.	16 38 10·66	− ·17	−5·46		5·03	16 38 26·88	21·85
ε Scorpii	16 43 33·50	·09	−0·02		33·39	16 43 55·10	21·71
η Ophiuchi	17 04 28·11	− ·07	+1·08		29·12	17 04 51·00	21·88
						Mean	21·80

Chronometer correction at $16^h\ 29^m = +21^s{\cdot}80$

μ Aquarii	20 47 05·08	− ·07	+1·44	Losing 1s·32 per day.	6·45	20 47 28·45	+22·00
32 Vulpeculæ	20 50 02·98	− ·04	+3·40		6·34	20 50 28·47	22·13
ι Piscis Aust.	20 55 02·04	− ·09	+0·09		2·04	20 55 24·04	22·00
β Aquarii	21 26 06·81	− ·07	+1·60		8·34	21 26 30·43	22·09
γ Gruis	21 47 45·33	− ·09	−0·30		44·94	21 48 07·00	22·06
α Aquarii	22 00 27·56	− ·06	+1·86		29·36	22 00 51·46	22·10
ι Pegasi	22 02 07·81	− ·04	+3·25		11·02	22 02 33·15	22·13
						Mean	22·07

Chronometer correction at $21^h\ 24^m = +22^s{\cdot}07$

TRANSIT OBSERVATIONS.

Station: SYDNEY. Date, October 7th, 1903. Observer, W. E. RAYMOND.

Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Rate.	Seconds of corr. transit.	R. A.	Chronometer correction.
	h. m. s.	s.	s.			h. m. s.	s.
ι Piscis Aust.	20 55 00·49	−·06	+·09	Losing 1s·43 per day.	0·52	20 55 24·03	+23·51
θ Capricorni.	21 00 08·56	·05	+·98		9·49	21 00 32·97	23·48
ι Capricorni.	21 16 29·61	−·05	+1·04		30·60	21 16 54·06	23·46
ζ Capricorni	21 20 47·06	−·06	+·73		47·73	21 21 11·18	23·45
β Aquarii	21 26 05·34	−·05	+1.60		6·89	21 26 30·41	23·52
ξ Aquarii	21 32 13·64	−·05	+1·50		15·09	21 32 38·59	23·50
ε Pegasi	21 39 02·65	−·04	+2·38		4·99	21 39 28·54	23·55
δ Capricorni	21 41 20·12	−·05	+1·04		21·11	21 41 44·62	23·51
α Aquarii	22 00 26·08	−·05	+1.86		27·89	22 00 51·45	23·56
ι Pegasi	22 02 06·28	−·03	+3·26		9·51	22 02 33·14	23·63
σ Aquarii	22 25 09·48	−·05	+1·35		10·78	22 25 34·29	23·51
η Aquarii	22 30 00·49	−·05	+1·86		2·30	22 30 25·76	23·46
						Mean.	23·51

Chronometer correction at $21^{h}\ 39^{m} = +23^{s}\cdot51$

TRANSIT OBSERVATIONS.

Station: SYDNEY. Date, October 8th, 1903. Observer, W. E. RAYMOND.

Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Rate.	Seconds of corr. transit.	R. A.	Chronometer correction.
	h. m. s.	s.	s.			h. m. s.	s.
ε Aquarii.	20 42 02·42	−·06	+1·38	Losing 1s·32 per day.	3·74	20 42 28·60	+24·86
μ Aquarii	20 47 02·29	−·06	+1·43		3·66	20 47 28·42	24·76
32 Vulpeculae	20 50 00·27	−·04	+3·37		3·60	20 50 28·44	24·84
ι Piscis Aust.	20 54 59·23	−·08	+0·09		59·24	20 55 24·01	24·77
θ Capricorni	21 00 07·22	−·07	-0·97		8·12	21 00 32·96	24·84
ι Capricorni	21 16 28·34	−·07	+1·02		29·29	21 16 54·04	24·75
ζ Capricorni	21 20 45·76	−·07	+0·71		46·40	21 21 11·16	24·76
β Aquarii	21 26 04·06	−·06	+1·58		5·58	21 26 30·40	24·82
ξ Aquarii	21 32 12·36	−·06	+1·48		13·78	21 32 38·58	24·80
ε Pegasi.	21 39 01·35	−·05	+2·35		3·65	21 39 28·53	24·88
δ Capricorni	21 41 18·84	−·07	+1·02		19·79	21 41 44·61	24·82
γ Gruis	21 47 42·57	−·08	−0·30		42·19	21 48 06·97	24·78
α Aquarii	22 00 24·75	−·06	+1·84		26·53	22 00 51·44	24·91
σ Aquarii	22 25 08·11	−·06	-1·33		9·38	22 25 34·28	24·90
						Mean.	24·82

Chronometer correction at $21^{h}\ 23^{m} = +24^{s}\cdot82$.

The following observations on November 5, January 22 and 23, were made for determining the differential personal equation between H. A. Lenehan, W. E. Raymond and Otto Klotz. The first two were the observers at Sydney during the longitude campaign, while the last was at Southport:—

PERSONAL EQUATION.

TRANSIT OBSERVATIONS.

Station: SYDNEY. Date, November 5th, 1903. Observer: W. E. RAYMOND.

Star.	Corrected transit over mean of threads.			R. A.			Chronometer correction.
	h.	m.	s.	h.	m.	s.	s.
ξ Aquarii	21	32	35·22	21	32	38·18	+2·96
ε Pegasi	21	39	25·15	21	39	28·12	2·97
δ Capricorni	21	41	41·29	21	41	44·20	2·91
16 Pegasi	21	48	38·76	21	48	41·75	2·99
α Aquarii	22	00	48·17	22	00	51·07	2·90
ι Pegasi	22	02	29·74	22	02	32·70	2·96
ι² Aquarii	23	04	16·87	23	04	19·74	2·87
ε Piscium	0	57	55·42	0	57	58·30	2·88
ζ¹ Piscium	1	08	40·64	1	08	43·61	2·97
				Mean			2·934

Chronometer correction at $23^h\ 25^m = +2^s{\cdot}934 \pm {}^s{\cdot}010$

PERSONAL EQUATION.

TRANSIT OBSERVATIONS.

Station: SYDNEY. Date, November 5th, 1903. Observer: OTTO KLOTZ.

Star.	Corrected transit over mean of threads.			R. A.			Chronometer correction.
	h.	m.	s.	h.	m.	s.	s.
γ Piscium	23	12	08·79	23	12	11·57	+2·78
τ Pegasi	23	15	50·90	23	15	53·64	2·74
κ Piscium	23	21	58·11	23	21	60·97	2·86
ι Phœnicis	23	29	52·08	23	29	54·76	2·68
ι Piscium	23	34	58·30	23	34	61·11	2·81
27 Piscium	23	53	43·09	23	53	45·89	2·80
2 Ceti	23	58	46·86	23	58	49·65	2·79
α Andromedæ	0	03	23·49	0	03	26·32	2·83
γ Pegasi	0	08	15·24	0	08	18·16	2·92
ι Ceti	0	14	29·89	0	14	32·60	2·71
44 Piscium	0	20	26·51	0	20	29·41	2·90
12 Ceti	0	25	05·95	0	25	08·87	2·92
ε Andromedæ	0	33	27·01	0	33	29·86	2·85
				Mean			2·815

Chronometer correction at $23^h\ 25^m = +2^s{\cdot}815 \pm {}^s{\cdot}015$

PERSONAL EQUATION.

TRANSIT OBSERVATIONS.

Station: SYDNEY. Date, November 5th, 1903. Observer: H. A. LENEHAN.

Star.	Corrected transit over mean of threads.	R.A.	Chronometer correction.
	h. m. s.	h. m. s.	s.
σ Aquarii	22 25 31·04	22 25 33·95	+2·91
η Aquarii	22 30 22·55	22 30 25·45	2·90
ζ Pegasi	22 36 37·66	22 36 40·62	2·96
η Pegasi	22 38 27·70	22 38 30·59	2·89
μ Pegasi	22 45 19·76	22 45 22·58	2·82
λ Aquarii	22 47 33·61	22 47 36·45	2·84
α Sculptoris	0 53 56·47	0 53 59·28	2·81
β Phœnicis	1 01 45·90	1 01 48·58	2·68
θ Ceti	1 19 11·35	1 19 14·11	2·76
		Mean	2·841

Chronometer correction at $23^h\ 25^m = +2^s{\cdot}841 \pm {}^s{\cdot}019$

PERSONAL EQUATION.

TRANSIT OBSERVATIONS.

Station: SYDNEY. Date, January 22nd, 1904. Observer: W. E. RAYMOND.

Star.	Corrected transit over mean of threads.	R.A.	Chronometer correction.
	h. m. s.	h. m. s.	s.
δ Eridani	3 38 08·37	3 38 39·67	+31·30
α Tauri	4 29 54·66	4 30 25·89	31·23
53 Eridani	4 33 16·85	4 33 48·00	31·15
π¹ Orionis	4 44 07·61	4 44 38·87	31·26
α Leporis	5 27 59·87	5 28 31·04	31·17
β Canis Majorum	6 17 58·51	6 18 29·82	31·31
ε Geminoris	6 37 32·11	6 38 03·24	31·13
		Mean	31·221

Chronometer correction at $5^h\ 32^m = +31^s{\cdot}221 \pm {}^s{\cdot}018$

PERSONAL EQUATION.

TRANSIT OBSERVATIONS.

Station: SYDNEY. Date, January 22nd, 1904. Observer: H. A. LENEHAN.

Star.	Corrected transit over mean of threads.	R.A.	Chronometer correction.
	h. m. s.	h. m. s.	s.
τ Tauri	4 35 59·13	4 36 30·24	+31·11
β Orionis	5 09 25·49	5 09 56·68	31·19
δ Orionis	5 26 36·23	5 27 07·42	31·19
α Columbæ	5 35 40·58	5 36 11·81	31·23
ζ Canis Majoris	6 16 08·08	6 16 39·23	31·15
γ Geminorum	6 31 40·34	6 32 11·56	31·22
		Mean	31·182

Chronometer correction at $5^h\ 32^m = +31^s{\cdot}182 \pm {}^s{\cdot}012$

PERSONAL EQUATION.

TRANSIT OBSERVATIONS.

Station: SYDNEY. Date, January 22nd, 1904. Observer: OTTO KLOTZ.

Star.	Corrected transit over mean of threads.	R. A.	Chronometer correction.
	h. m. s.	h. m. s.	s.
μ Eridani	4 40 11·99	4 40 43·23	+31·24
ε Leporis	5 00 53·88	5 01 25·01	31.13
γ Orionis	5 19 28·90	5 19 60·22	31·32
ε Orionis	5 30 50·54	5 31 21·84	31·30
η Geminorum	6 08 35·40	6 09 06·56	31·16
ν Geminorum	6 22 46·16	6 23 17·37	31·21
ξ Geminorum	6 39 24·43	6 39 55·65	31·22
		Mean	31·226

Chronometer correction at 5^h $32^m = +31^s{\cdot}226 \pm {}^s{\cdot}017$

PERSONAL EQUATION.

TRANSIT OBSERVATIONS.

Station: SYDNEY. Date, January 23rd, 1904. Observer: W. E. RAYMOND.

Star.	Corrected transit over mean of threads.	R. A.	Chronometer correction.
	h. m. s.	h. m. s.	s.
γ¹ Eridani	3 53 01·26	3 53 33·80	+32·54
τ Tauri	4 35 57·74	4 36 30·23	32·49
ε Leporis	5 00 52·32	5 01 25·00	32·68
δ Orionis	5 26 34·66	5 27 07·41	32·75
κ Orionis	5 42 40·91	5 43 13·56	32·65
β Canis Majoris	6 17 57·12	6 18 29·81	32·69
		Mean	32·633

Chronometer correction at 5^h $20^m = +32^s{\cdot}633 \pm {}^s{\cdot}027$

PERSONAL EQUATION.

TRANSIT OBSERVATIONS.

Station: SYDNEY. Date, January 23rd, 1904. Observer: H. A. LENEHAN.

Star.	Corrected transit over mean of threads.	R. A.	Chronometer correction.
	h. m. s.	h. m. s.	s.
o¹ Eridani	4 06 39·21	4 07 11·64	+32·43
μ Eridani	4 40 10·70	4 40 43·22	32·52
β Orionis	5 09 24·04	5 09 56·67	32·63
ε Orionis	5 30 49·19	5 31 21·83	32·64
η Geminorum	6 08 33·94	6 09 06·55	32·61
ν Geminorum	6 22 44·72	6 23 17·37	32·65
		Mean	32·580

Chronometer correction at 5^h $20^m = +32^s{\cdot}580 \pm {}^s{\cdot}024$

PERSONAL EQUATION.

TRANSIT OBSERVATIONS.

Station: SYDNEY. Date, January 23rd, 1904. Observer: OTTO KLOTZ.

Star.	Corrected transit over mean of threads.	R. A.	Chronometer correction.
	h. m. s.	h. m. s.	s.
53 Eridani	4 33 15·49	4 33 47·99	+32·50
π^1 Orionis	4 44 06·28	4 44 38·86	32·58
γ Orionis	5 19 27·60	5 19 60·22	32·62
α Columbæ	5 35 39·12	5 36 11·80	32·68
ζ Canis Majoris	6 16 06·60	6 16 39·22	32·62
γ Geminorum	6 31 38·87	6 32 11·56	32·69
		Mean	32·615

Chronometer correction at $5^h\ 20^m = +32^s{\cdot}615 \pm {}^s{\cdot}019$

PERSONAL EQUATION.

Date.	Clock Correction. Klotz.	Lenehan.	Raymond.	K–L	K–R
	s. s.	s. s.	s. s.	s.	s.
Nov. 5, 1903	+ 2·815±·015	+ 2·841±·019	+ 2·934±·010	–·026	–·119
Jan. 22, 1904	+31·226±·017	+31·182±·012	+31·221±·018	+·044	+·005
" 23, 1904	+32·615±·019	+32·580±·024	+32·633±·027	+·035	–·018
Weighted				+·018±·015	–·067±·027

That is, Klotz anticipates Lenehan, and Raymond anticipates Klotz.

TRANSIT OBSERVATIONS.

Station: Brisbane. Date, September 29th, 1903. Observer: Thos. D. Fraser.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·01	s.		h. m. s.	s.	s.
E	δ Pavonis...	19 58 33·55	− ·02	+ ·04	−1·16	·01	05	32·39	19 59 17 93	+45·54	− ·17
	α Capricorni ..	20 11 58·09	− ·02	·01	·48	− ·01	− ·02	57·59	20 12 43·52	·93	− ·22
	β Capricorni. ..	14 51·55	− ·02	·01	·48	·01	− ·02	51 05	15 36·88	·83	− ·12
	γ Cygni.... ..	18 02·46	·01	− ·03	69	·01	− ·02	01·87	18 47 56	69	− ·02
	ρ Capricorni....	22 37·70	− 02	·00	49	·00	·02	37 21	23 22·95	74	− ·03
	α Delphini	34 25·75	− ·01	− 02	·48	00	− ·02	25·24	35 10·93	·69	− ·02
	ε Aquarii......	41 43·43	− 02	·01	− ·47	·00	·02	42 95	42 28 73	·78	·07
W	θ Capricorni....	59 47·05	·02	·00	− 49	·00	·02	47 50	21 00 33 08	·58	− ·13
	ζ Cygni...... ..	21 08 05·56	01	02	− ·53	·00	02	06·04	08 51 65	·61	− ·10
	γ Pavonis.....	17 43·89	·05	+ ·04	1·13	·00	− 05	44·96	18 30·81	·85	− ·14
	ζ Capricorni. ..	20 25·05	− ·02	·00	·50	·01	·02	25·52	21 11·28	·76	·05
	β Aquarii	25 44.47	·02	·01	− ·47	− ·01	− ·02	44·90	26 30·51	·61	− ·10
	ξ Aquarii... ..	31 52·57	·02	·01	·47	− 01	− ·02	53·00	32 38 69	·69	− ·02
	δ Capricorni....	40 58·62	− ·02	·00	− ·48	·01	·02	59 07	41 44·72	·65	− ·06

$a = +^{s}\cdot024 \quad c = -^{s}\cdot462$

Chronometer correction at $20^{h}\ 50^{m} = +45^{s}\ 715 \pm {}^{s}\cdot022$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	σ Aquarii......	22 24 48·31	− ·10	·02	+ ·47	− ·01	− ·02	48·63	22 25 34·35	+45·72	− ·02
	η Aquarii ..	29 39 76	− ·09	− ·04	+ ·46	·00	− ·02	40 07	30 25·82	·75	− ·01
	ε Poisson.	34 34·97	− ·11	·00	+ ·52	00	− ·02	35·36	35 21·07	·71	− ·03
	η Pegasi.......	37 44 98	− ·08	− ·08	− ·53	00	− ·02	45·33	38 31·03	·70	− ·04
	ε Gruis........	41 59·49	− ·14	+ ·06	− ·75	·00	− ·03	60 13	42 45·83	·70	− ·04
	λ Aquarii.....	46 50·69	− ·09	− ·03	+ ·46	00	− ·02	51 01	47 36·79	·78	− ·04
	δ Aquarii....	48 47·49	− ·10	− ·02	+ ·48	·00	− ·02	47·83	49 33·70	·87	− ·13
E	α Pegasi.......	59 14·26	− ·01	− ·06	− ·47	·00	− ·02	13·70	59 59·38	·68	+ ·06
	c^2 Aquarii......	23 03 34·78	·02	− ·01	− ·50	·00	− ·02	34·23	23 04 20·07	·84	− ·10
	γ Toucani. ..	11 05 52	− ·02	+ ·09	− ·89	·00	− ·04	04·66	11 50·33	·67	+ ·07
	τ Pegasi.. ..	15 08·81	·01	·07	− ·50	·00	− ·02	08·21	15 53·92	·71	+ ·03
	κ Piscium......	21 16·05	− ·01	− ·04	− ·46	·00	− ·02	15·52	22 01·20	·68	+ ·06
	ι Piscium......	34 16·07	− ·01	− ·05	− ·46	+ ·01	− ·02	15·54	35 01·30	·76	− ·02

$a = +^{s}\cdot086 \quad c = -^{s}\cdot461$

Chronometer correction at $22^{h}\ 57^{m} = +45^{s}\ 737 \pm {}^{s}\cdot014$

TRANSIT OBSERVATIONS.

Station : BRISBANE. Date, October 2nd, 1903. Observer : THOS. D. FRASE

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	r = · ·02	s.		h. m. s.	s.	s.
E	α^2 Capricorni....	20 11 56·84	+ ·04	·03	·42	·01	·02	56·40	20 12 43·46	+47·06	+ ·15
	β Capricorni....	14 50·06	· ·04	·03	· ·42	·01	– ·02	49·62	15 36·84	·22	·01
	γ Cygni	18 00·93	· ·02	·16	– ·53	· 01	·02	00 23	18 47·49	·29	– ·05
	ρ Capricorni....	22 36·14	+ ·04	·02	·43	·01	– ·02	35·70	23 22·90	·20	+ ·01
	β Pavonis....	35 31·86	· ·07	· ·22	·1·01	·01	05	31·08	36 18 40	·32	·11
	ϵ Aquarii	41 41·96	· ·04	– ·04	– ·41	· ·01	·02	41·52	42 28·68	·16	· ·05
	μ Aquarii	46 41·76	· ·04	·04	– ·41	·00	·02	41·33	47 28·51	·18	+ ·03
W	ζ Cygni........	21 08 04·00	·02	·13	+ ·47	·00	– ·02	04·30	21 08 51·59	·29	– ·08
	γ Pavonis.......	17 42·43	·06	+ ·21	+ ·99	+ ·01	– ·05	43·53	18 30·70	·17	+ ·04
	ζ Capricorni....	20 23·63	·03	·01	– ·44	+ ·01	·02	24·02	21 11·24	·22	·01
	β Aquarii......	25 43·01	·03	· ·05	+ ·41	+ ·01	– ·02	43·33	26 30·48	·15	+ ·06
	ξ Aquarii......	31 51·01	·03	– ·04	· ·41	+ ·01	– ·02	51·34	32 38·66	·32	·11
	γ Capricorni....	33 58·90	·03	·03	– ·43	+ ·01	· ·02	59·26	34 46·47	·21	·00
	δ Capricorni....	40 57·13	· ·03	·03	+ ·42	·01	· ·02	57·48	41 44·69	·21	·00

$a = + ^s·138$ $c = - ^s·404$

Chronometer correction at $20^h\ 56^m = 47^s·215 \pm ^s·014$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	γ Aquarii	22 15 54·75	– ·06	·04	+ ·50	– ·02	– ·02	55·11	22 16 42·21	+47·10	+ ·10
	η Aquarii	29 38·19	– ·05	– ·04	– ·50	· 01	– ·02	38·57	30 25·80	·23	·03
	ϵ Poisson.....	34 33·34	– ·06	·00	– ·57	·01	– ·02	33·82	35 21·05	·23	– ·03
	η Pegasi.	37 43·35	– ·04	– ·08	– ·58	·01	– ·02	43·78	38 31·00	·22	·02
	ϵ Gruis	41 58·04	·08	+ ·06	· ·81	– ·01	– ·03	58·79	42 45·79	·00	+ ·20
	λ Aquarii.......	46 49·23	– ·05	– ·02	+ ·51	·01	– ·02	49·64	47 36·77	·13	+ ·07
	δ Aquarii	48 46·13	– ·05	·02	+ ·52	· ·01	– ·02	46·55	49 33·68	·13	+ ·07
E	c^2 Aquarii	23 03 33·41	– ·02	– ·01	– ·51	·00	– ·02	32·82	23 04 20·06	·24	– ·04
	γ Toucani......	11 03·92	– ·03	+ ·08	·97	·00	– ·03	02·97	11 50·30	·33	– ·13
	τ Pegasi	15 07·43	– ·01	– ·07	– ·55	·00	– ·02	06·78	15 53·91	·13	+ ·07
	κ Piscium	21 14·47	– ·01	– ·04	·50	+ ·01	– ·02	13·91	22 01·19	·28	– ·08
	ι Piscium	34 14·61	·01	·05	·51	+ ·01	– ·02	14·03	35 01·29	·26	– ·06
	δ Sculptoris	43 09·27	– ·02	·00	– ·57	+ ·01	– ·02	08·67	43 56·00	·33	·13
	27 Piscium.....	52 59·36	– ·01	– ·03	·50	+ ·02	– ·02	58·82	53 46·02	·20	·00

$a = + ^s·083$ $c = ^s·502$

Chronometer correction at $23^h\ 04^m = +47^s·200 \pm ^s·018$

TRANSIT OBSERVATIONS.

Station: BRISBANE. Date, October 3rd, 1903. Observer: THOS. D. FRASER.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = + ·01	s.		h. m. s.	s.	s.
E	α^2 Capricorni ...	20 11 56·03	·00	− ·02	− ·51	·01	− ·02	55 47	20 12 43·45	+47·98	− ·03
	β Capricorni	14 49·33	·00	− ·02	− ·51	·01	− ·02	48·77	15 36·82	48·05	− ·10
	γ Cygni	17 60·16	·00	− ·09	− ·64	·01	− ·02	59·40	18 47·46	·06	− 11
	ρ Capricorni ...	22 35·49	·00	− ·01	− ·52	·01	− ·02	34·93	23 22·88	47·95	·00
	β Pavonis.......	35 31 57	·00	+ ·12	−1·23	·00	− ·05	30·41	36 18·36	·95	·00
	ψ Capricorni	39 37 24	·00	·00	− ·55	·00	− ·02	36·67	40 24·55	·88	+ ·07
	ϵ Aquarii.....	41 41·31	·00	− ·02	− ·50	·00	− ·02	40 77	42 28·69	·92	+ ·03
W	ζ Cygni	21 08 03·24	− ·02	− ·07	+ ·56	·00	− ·02	03·69	21 08 51·58	·89	+ ·06
	γ Pavonis......	17 41 46	− ·06	+ ·11	+1·20	·00	− ·05	42·66	18 30·67	48·01	− ·06
	ζ Capricorni.....	20 22·86	− ·04	− ·01	+ ·54	·00	− ·02	23 33	21 11·23	47·90	+ ·05
	β Aquarii.....	25 42·14	− ·03	− ·02	+ ·50	·00	− ·02	42·57	26 30·46	·89	+ ·06
	ξ Aquarii.......	31 50·37	− ·03	− ·02	+ ·50	·01	− ·02	50·81	32 38·64	·83	+ ·12
	γ Capricorni....	33 57·98	− ·03	− ·01	+ ·52	+ ·01	− ·02	58·45	34 46·48	48·03	− ·08
	δ Capricorni.....	40 56·22	− ·03	− ·02	+ ·51	+ ·01	− ·02	56·67	41 44·67	48·00	− ·05

$a = -{}^{s}{\cdot}079 \qquad c = -{}^{s}{\cdot}491$

Chronometer correction at $20^{h}\,56^{m} = +47^{s}{\cdot}954 \pm {}^{s}{\cdot}014$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	σ Aquarii.......	22 24 46·04	− ·05	·00	+ ·45	·01	− ·02	46·41	22 25 34·32	+47·91	− ·06
	η Aquarii.......	29 37·50	− ·05	·00	+ ·44	− ·01	− ·02	37·86	30 25·79	·93	+ ·04
	ϵ Poisson.......	34 32·59	− ·06	·00	+ ·50	·01	− ·02	33·00	35 21·04	48·04	− ·07
	η Pegasi........	37 42·65	− ·04	+ ·01	+ ·51	− ·01	− ·02	43·10	38 30·99	·89	− ·08
	ϵ Gruis........	41 57·19	− ·08	− ·01	·72	− ·01	− ·03	57·78	42 45·77	·99	− ·02
	λ Aquarii. . .	46 48·39	− ·05	·00	+ ·45	·01	− ·02	48·76	47 36·76	48·00	·03
	δ Aquarii.......	48 45·28	− ·06	·00	+ ·46	− ·01	− ·02	45·65	49 33·67	·02	− 05
E	c^2 Aquarii.....	23 03 32·53	·00	·00	− ·48	·00	− ·02	32·03	23 04 20·05	·02	− ·05
	γ Toucani.......	11 03·26	·00	− ·01	− ·86	·00	− ·03	02·36	11 50·29	47·93	− ·04
	τ Pegasi.......	15 06·32	·00	+ ·01	− ·48	·00	− ·02	05·83	15 53·91	48·08	− ·11
	κ Piscium.......	21 13·70	·00	·00	− ·44	·00	− ·02	13·24	22 01·18	47·94	− ·03
	ι Piscium.....	34 13·84	·00	·00	− ·45	+ ·01	− ·02	13·38	35 01·29	·91	+ ·06
	δ Sculptoris.....	43 08·55	·00	·00	·51	+ ·01	− ·02	08·03	43 56·00	·97	·00
	27 Piscium.......	52 58·49	·00	·00	− ·44	+ ·01	− ·02	58·04	53 46·02	·98	− ·01

$a = -{}^{s}{\cdot}006 \qquad c = -{}^{s}{\cdot}444$

Chronometer correction at $23^{h}\,08^{m} = +47^{s}{\cdot}971 \pm {}^{s}{\cdot}012$

TRANSIT OBSERVATIONS.

Station : Brisbane. Date, October 6th, 1903. Observer : Thos. D. Fraser.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = + ·01	s.		h. m. s.	s.	s.
E	ρ Capricorni	20 22 32·64	− ·01	− ·02	− ·46	·01	− ·02	32·12	20 23 22·83	+50·71	− ·07
	β Pavonis	35 28·42	− ·01	+ ·33	−1·10	·01	− ·05	27·58	36 18·23	·65	·01
	ψ Capricorni ..	39 34·43	− ·01	− ·01	− ·49	·01	− ·02	33·89	40 24·50	·61	− ·03
	ε Aquarii......	41 38·55	− ·01	− ·06	− ·44	·01	− ·02	38·01	42 28·62	·61	+ ·03
	μ Aquarii......	46 38·45	− ·01	− ·06	− ·44	·00	− ·02	37·92	47 28·45	·53	+ ·11
	32 Vulpeculæ....	49 38·50	·00	− ·19	− ·49	·00	− ·02	37·80	50 28·47	·67	·03
	θ Capricorni	59 42·95	− ·01	− ·04	− ·46	·00	− ·02	42·42	60 32·99	·57	+ ·07
W	γ Pavonis	21 17 38·86	− ·17	+ ·30	+1·07	·00	− ·05	40·01	21 18 30·56	·55	+ ·09
	ζ Capricorni	20 20·11	− ·10	− ·02	+ ·48	·00	− ·02	20·45	21 11·19	·74	·10
	β Aquarii....	25 39·50	− ·08	− ·07	+ ·44	·00	− ·02	39·77	26 30·43	·66	− ·02
	ξ Aquarii.. ..	31 47·70	− ·09	− ·07	+ ·44	·00	− ·02	47·96	32 38·61	·65	·01
	ε Pegasi	38 37·71	− ·07	− ·12	+ ·44	·00	− ·02	37·94	39 28·56	·62	+ ·02
	δ Capricorni	40 53·67	− ·09	− ·04	+ ·46	·00	− ·02	53·98	41 44·64	·66	− ·02
	ι Pegasi	22 01 42·26	− ·06	− ·17	+ ·48	− ·01	− ·02	42·50	22 02 33·15	·65	·01

$a = {}^{s}\cdot204$ $c = {}^{s}\cdot438$

Chronometer correction at $21^{h}\ 12^{m} = +50^{s}\cdot636 \pm {}^{s}\cdot012$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	ε Gruis	22 41 54·57	− ·26	+ ·02	+ ·75	− ·01	− ·03	55·04	22 42 45·74	+50·70	·06
	μ Pegasi......	44 32·05	·12	− ·03	+ ·50	− ·01	− ·02	32·37	45 22·91	·54	+ ·10
	λ Aquarii	46 45·86	− ·17	·01	+ ·47	− ·01	− ·02	46·12	47 36·74	·62	+ ·02
	δ Aquarii... ...	48 42·77	− ·18	− ·01	+ ·48	− ·01	− ·02	43·03	49 33·65	·62	+ ·02
	α Piscis Aust ...	51 30·08	− ·20	·00	+ ·54	·00	− ·02	30·40	52 21·08	·68	− ·04
	c^2 Aquarii.	23 03 29·13	− ·19	·00	− ·50	·00	− ·02	29·42	23 04 20·04	·62	+ ·02
E	γ Toucani......	11 00·80	− ·22	+ ·03	·89	·00	− ·03	59·69	11 50·26	·57	+ ·07
	κ Piscium.......	21 11·19	− ·12	− ·02	·46	·00	− ·02	10·57	22 01·18	·61	+ ·03
	ι Piscium.......	34 11·27	− ·11	·02	− ·47	·00	− ·02	10·65	35 01·29	·64	·00
	δ Sculptoris.....	43 06·00	− ·15	·00	·53	·00	− ·02	05·30	43 56·00	·70	− ·06
	φ Pegasi........	46 46·91	− ·10	− ·02	− ·49	·00	·02	46·28	47 36·98	·70	·06
	27 Piscium.......	52 55·99	− ·13	− ·01	·46	+ ·01	− ·02	55·38	53 46·03	·65	− ·01
	2 Ceti	57 59·80	− ·14	− ·01	·48	+ ·01	− ·02	59·16	58 49·80	·64	·00

$a = + {}^{s}\cdot034$ $c = - {}^{s}\cdot462$

Chronometer correction at $23^{h}\ 19^{m} = +50^{s}\cdot638 \pm {}^{s}\cdot010$

TRANSIT OBSERVATIONS.

Station : BRISBANE. Date, October 7th, 1903. Observer : THOS. D. FRASER.

Clamp	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = + ·01	s.		h. m. s.	s.	s.
E	ρ Capricorni....	20 22 31·81	09	·02	·53	·01	·02	31·32	20 23 22·81	+51 ·49	−·01
	β Pavonis....	35 27·67	17	+·23	−1·26	·01	−·05	26·75	36 18·19	·44	−·04
	υ Capricorni...	39 33·40	10	−·01	56	·00	−·02	32·91	40 24·49	·58	−·10
	ι Cygni	41 29·21	+·05	−·16	60	00	−·02	28·48	42 20·00	·52	−·04
	α Aquarii ...	46 37·51	+·08	−·05	51	·00	−·02	37·01	47 28·44	·43	+·05
	32 Vulpeculæ...	49 37·70	+·05	−·14	57	·00	−·02	37·03	50 28·46	·43	+·05
	θ Capricorni..	59 41·88	09	−·03	53	00	·02	41·39	21 00 32·93	·54	·06
W	γ Pavonis......	21 17 37·49	11	+·22	1·22	00	−·05	38·99	18 30·52	·53	−·05
	ζ Capricorni ..	20 19·13	+·07	−·01	+·55	·00	−·02	19·72	21 11·18	·46	+·02
	β Aquarii. ...	25 38·51	06	−·05	+·51	00	−·02	39·01	26 30·41	·40	+·08
	ξ Aquarii ..	31 46·61	06	−·05	51	00	−·02	47·11	32 38·60	·49	−·01
	γ Capricorni..	35 54·39	+·06	−·03	53	·00	−·02	54·93	34 46·41	·48	·00
	δ Capricorni .	40 52·62	+·06	−·03	+·52	+·01	−·02	53·16	41 44·63	·47	+·01
	16 Pegasi ...	47 50·28	04	−·13	56	+·01	−·02	50·74	48 42·20	·46	+·02

$a = +^{s}\cdot 153$ $c = -^{s}\cdot 503$

Chronometer correction at $21^{h}\ 05^{m} = +51^{s}\cdot 479 \pm {}^{s}\cdot 010$

Clamp	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	δ Aquarii. ..	22 48 41·60	+·09	01	·43	01	−·02	42·08	22 49 33·65	+51·57	·05
	α Pegasi..	59 07·37	+·06	−·04	·43	01	−·02	07·79	59 59·34	·55	−·03
	c² Aquarii .	23 03 27·93	+·09	−·01	+·45	00	−·02	28·44	23 04 20·04	·60	·08
	γ Toucani	10 58·01	+·13	+·06	·80	·00	−·03	58·97	11 50·25	·28	+·24
	τ Pegasi........	15 01·92	+·06	−·05	45	·00	−·02	02·36	15 53·89	·53	·01
	ι Piscium	21 09·16	+·07	−·03	+·41	·00	−·02	09·59	21 61·17	·58	·06
	ι Piscium ...	34 09·29	+·07	−·04	·41	00	−·02	09·71	35 01·29	·58	−·06
E	δ Sculptoris...	43 04·80	13	00	47	·00	−·02	04·44	43 56·00	·56	·04
	φ Pegasi........	46 45·88	·09	−·05	44	00	−·02	45·46	47 36·98	·52	·00
	27 Piscium	52 54·81	·11	−·03	41	·00	−·02	54·46	53 46·03	·57	·05
	30 Poisson.. ..	56 11·56	+·11	−·02	42	·00	−·02	11·21	57 02·72	·51	+·01
	2 Ceti..	57 58·63	·12	−·01	43	·00	−·02	58·29	58 49·80	·51	+·01
	α Andromedæ...	24 02 35·37	+·08	·06	47	+·01	−·02	34·91	24 03 26·45	·54	·02
	ζ Toucani....	14 14·84	·23	+·09	−1·00	+·01	−·04	14·13	15 05·55	·42	−·10

$a = +^{s}\cdot 063$ $c = -^{s}\cdot 413$

Chronometer correction at $23^{h}\ 31^{m} = +51^{s}\cdot 522 \pm {}^{s}\cdot 016$

PERSONAL EQUATION.

TRANSIT OBSERVATIONS.

Station : SOUTHPORT. Date, October 23rd, 1903. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m s.	s.	s.	s.	s. r = – ·45	s.		h. m. s.	m. s.	s.
E	α Toucani	22 16 35·30	+ ·15	+ ·54	– ·30	+ ·62	– ·04	36·27	22 11 55 37	–4 40·90	+ ·05
	γ Aquarii	21 22·62	+ ·08	– ·21	– ·14	+ ·59	– ·02	22·92	16 41·99	·93	+ ·08
	σ Aquarii	30 14·71	+ ·08	– ·14	– ·15	+ ·52	– ·02	15·09	25 34·12	·88	+ ·03
	η Aquarii	35 06·23	+ ·08	– ·22	– ·14	+ ·48	– ·02	06·41	30 25·59	·82	·03
	ζ Pegasi	41 21·56	+ ·07	– ·30	– ·15	+ ·44	– ·02	21·60	36 46·78	·82	·03
	η Pegasi	43 11·73	+ ·05	– ·47	– ·17	+ ·42	– ·02	11·54	38 30·78	·76	·09
	μ Pegasi	50 03·71	+ ·06	– ·42	– ·16	+ ·37	– ·02	03·54	45 22·78	·76	·09
W	δ Sculptoris	23 48 36·97	– ·16	·00	+ ·16	·07	– ·02	36·88	23 43 55·91	·97	+ ·12
	φ Pegasi	52 18·32	·16	– ·37	+ ·15	·10	– ·02	17·88	47 36·92	·96	+ ·11
	ω Piscium	59 04·67	– ·10	– ·28	+ ·15	·15	·02	04·27	54 23·43	·84	·01
	2 Ceti	24 03 30·86	– ·12	·09	+ ·15	·18	– ·02	30·60	58 49 75	·85	·00
	α Andromedæ	08 07·85	– ·07	– ·46	+ ·16	·22	– ·02	07·24	24 03 26·41	·83	·02
	γ Pegasi	12 59·56	– ·08	– ·34	+ ·15	·25	– ·02	59·02	08 18·22	·80	·05
	ζ Toucani	19 45·62	– ·21	+ ·71	+ ·35	·30	– ·05	46·12	15 05·37	·75	– ·10

$a = +{}^{s}\cdot484$ $c = -{}^{s}\cdot144$

Chronometer correction at $23^{h}\ 39^{m} = -4^{m}\ 40^{s}\cdot848 \pm {}^{s}\cdot015$

Observer: THOS. D. FRASER.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
						r = – ·45					
E	α Pegasi	23 04 39·98	+ ·11	·31	·14	+ ·26	– ·02	39·88	22 59 59·21	–4 40·67	·09
	θ² Aquarii	09 00·42	+ ·16	·05	– ·14	+ ·23	– ·02	00·60	23 04 19·90	·70	·06
	γ Toucani	16 30 19	+ ·25	+ ·44	·26	+ ·17	– ·04	30 75	11 49 95	·80	+ ·04
	τ Pegasi	20 34·82	+ ·10	·38	– ·15	+ ·14	– ·02	34·51	15 53·78	·73	– ·03
	κ Piscium	26 41·57	+ ·13	·21	·13	+ ·10	– ·02	41·84	21 61·08	·76	·00
	ι Phœnicis	34 35·63	+ ·29	·16	18	+ ·04	– ·03	35·82	29 54·95	·87	+ 11
	ι Piscium	39 42·17	+ ·13	·24	– ·13	·00	– ·02	41·91	35 01·22	·69	– ·07
W	β Hydri	0 25 24·31	·39	+ 1·60	+ ·63	·34	– ·09	25·72	0 20 45·01	·71	·05
	12 Ceti	29 50·41	– ·12	·18	+ ·13	– ·38	– ·02	49·84	25 08·92	·92	– ·16
	ε Andromedæ	38 11·49	·08	·42	+ ·15	·44	– ·02	10·68	33 29·91	·77	+ ·01
	β Ceti	43 28·17	– ·14	·08	+ 14	·48	– ·02	27·59	38 46·77	·82	+ ·06
	δ Piscium	48 24·28	– ·11	– ·26	+ ·14	– ·52	– ·02	23·51	43 42·74	·77	+ ·01
	20 Ceti	52 48·22	– ·12	·20	+ ·13	·55	– ·02	47·46	48 06·70	·76	·00
	μ Andromedæ	56 08·41	·06	·51	+ ·17	·58	– ·02	07·41	51 26·68	·73	·03

$a = +{}^{s}\cdot443$ $c = -{}^{s}\cdot134$

Chronometer correction at $23^{h}\ 39^{m} = -4^{m}\ 40^{s}\cdot765 \pm {}^{s}\cdot014$

PERSONAL EQUATION.

TRANSIT OBSERVATIONS.

Station : BRISBANE. Date, October 29th, 1903. Observer, OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = - ·02	s.		h. m. s.	m. s.	s.
E	μ Pegasi	22 44 16·22	- ·02	- ·02	·43	·02	·02	15·79	22 45 22·67	+1 06.88	+ ·04
	λ Aquarii	46 29·93	- ·03	- ·01	·40	·02	·02	29·53	47 36·53	07·00	·08
	δ Aquarii	48 26·88	- ·04	- ·01	·41	·02	·02	26·48	49 33·44	06·96	- ·04
	α Pegasi	58 52·61	- ·03	- ·02	·41	·01	·02	52·22	59 59·14	·92	·00
	c^2 Aquarii	23 03 13·31	- ·04	·00	·43	·01	·02	12·89	23 04 19·83	·94	- .02
	γ Toucani	10 43·69	- ·06	- ·02	·76	·01	·03	42·93	11 49·81	·88	- ·04
	τ Pegasi	14 47·28	- ·03	- ·02	- ·43	·01	·02	46·87	15 53·71	·84	+ ·08
W	12 Ceti	24 24 01·55	·03	- ·01	+ ·39	- ·02	·02	01·92	24 25 08·91	·99	·07
	β Ceti	37 39·34	·03	·00	+ ·41	- ·02	·02	39·72	38 46·76	07·04	·12
	δ Piscium	42 35·42	·03	+ ·01	+ ·40	- ·02	·02	35·80	43 42·73	06·93	- ·01
	20 Ceti	46 59·39	·03	- ·01	+ ·39	- ·02	·02	59·76	48 06·69	·93	·01
	ϵ Piscium	56 51·05	·03	+ ·01	+ ·40	·03	·02	51·44	57 58·32	·88	+ ·04
	β Phœnicis	25 00 41·31	·06	·01	+ ·60	- ·03	·03	41·84	25 01 48·64	·80	- ·12
	θ Ceti	18 06·85	·04	+ ·01	- ·40	- ·03	·02	07·23	19 14·11	·88	- ·04

$a = -^s{\cdot}025$ $c = -^s{\cdot}394$

Chronometer correction at $23^h\ 35^m = +1^m 06^s{\cdot}918 \pm {}^s{\cdot}013$

Observer, THOS. D. FRASER.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
						r = + ·02					
E	α Aquarii	21 59 44·44	+ ·03	+ ·08	- ·50	·03	- ·02	44·00	22 00 51·17	+1 07.17	·04
	ι Pegasi	22 01 26·06	+ ·02	+ ·16	- ·55	·03	- ·02	25·64	02 32·81	·17	- ·04
	α Toucani	10 49·27	+ ·06	- ·21	-1·03	·03	- ·04	48·02	11 55·17	·15	- ·02
	γ Aquarii	15 35·20	+ ·03	+ ·08	- ·50	·03	- ·02	34·76	16 41·92	·16	- ·03
	σ Aquarii	24 27·38	+ ·03	- ·05	- ·51	·02	- ·02	26·91	25 34·05	·14	- ·01
	η Aquarii	29 18·86	+ ·03	+ ·08	- ·50	·02	- ·02	18·43	30 25·54	·11	+ ·02
	ζ Pegasi	35 34·04	+ ·03	+ ·12	- ·51	·02	- ·02	33·64	36 40·71	·07	- ·06
W	ι Piscium	23 33 53·66	+ ·03	·04	+ ·51	·00	- ·02	54.14	23 34 61·17	·03	- ·10
	δ Sculptoris	42 48·09	+ ·04	·00	+ ·57	·00	- ·02	48·68	43 55·86	·18	- ·05
	ϕ Pegasi	46 29·28	+ ·02	- ·05	+ ·53	·00	- ·02	29·76	47 36·89	·13	·00
	27 Piscium	52 38·41	+ ·03	·03	+ ·50	+ ·01	- ·02	38·90	53 45·95	·05	+ ·08
	2 Ceti	57 42·11	+ ·03	·01	+ ·53	+ ·01	- ·02	42·65	58 49·71	·06	+ ·07
	α Andromedæ	24 02 18·57	+ ·02	- ·07	+ ·57	+ ·01	- ·02	19·08	24 03 26·38	·30	- ·17
	β Hydri	19 34·98	+ ·10	+ ·26	+2·37	+ ·01	- ·09	37·63	20 44·77	·14	- ·01

$a_1 = -^s{\cdot}188$ $a_2 = +^s{\cdot}072$ $c = -^s{\cdot}500$

Chronometer correction at $23^h\ 35^m = +1^m 07^s{\cdot}134 \pm {}^s{\cdot}014$

Hence the weighted personal equation of the two values, Fraser anticipates Klotz $^s{\cdot}153 \pm {}^s{\cdot}044$

TRANSIT OBSERVATIONS.

Station : NORFOLK ISLAND. Date, December 5th, 1903. Observer, F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·45	s.		h. m. s.	s.	s.
E	β Phœnicis......	1 02 06·26	− ·05	+ ·30	− ·70	+ .28	− ·03	06·06	1 01 48·11	17·92	+ ·01
	ζ¹ Piscium.......	09 02·07	− ·03	− ·39	− ·48	+ ·23	− ·02	01·38	08 43·46	17·92	+ ·01
	21....	19 32·49	− ·03	− ·23	− ·48	+ ·16	− ·02	31·89	19 13·95	17·94	+ ·03
	γ Phœnicis.....	24 30·57	− ·05	+ ·23	− ·66	+ ·12	− 03	30·18	24 12·18	18·00	· 09
	22..............	26 40·20	− ·03	− ·47	− ·49	+ ·10	− ·02	39·29	26 21·44	17·85	06
	α Eridani........	34 26·98	− ·06	+ ·59	− ·89	+ ·04	− ·03	26·63	34 08·89	17·74	− 17
	ν Piscium.......	36 45·53	− ·03	− ·39	− ·48	+ ·03	− ·02	44·64	36 26·75	17·89	·02
W	542..	39 54·84	− ·08	− ·14	+ ·49	+ ·01	− ·02	55·10	39 37·01	18·09	+ ·18
	544..	47 01·76	− ·08	− ·21	+ ·48	− ·05	− ·02	01·88	46 43·87	18·01	− ·10
	37......	2 23 22·30	− ·02	− ·40	+ ·48	− ·32	− ·02	22·02	2 22 64·09	17·93	− ·02
	σ Baleine..	27 50·85	− ·02	− ·16	+ ·49	− ·35	− ·02	50·79	27 32·95	17·84	·07
	ν Ceti.	31 09·18	− ·02	− ·26	+ ·48	− ·38	− ·02	08·98	30 50·99	17·99	− 08
	355..............	33 41·13	− ·02	− ·54	+ ·51	− ·40	·02	40·66	33 22·89	17·77	·14
	39.......... ...	34 52·55	− ·02	− ·32	+ ·48	− ·41	− ·02	52·26	34 34·49	17·77	·14

$a = +^s{\cdot}657$ $c = -^s.475$

Chronometer correction at $1^h\ 40^m = -17^s{\cdot}905 \pm {}^s{\cdot}023$

W	547.	2 39 52·15	− ·02	·13	+ ·46	+ ·23	− ·02	52·67	2 39 33·97	−18·70	+ ·12
	β Fornacis......	45 23·12	− ·02	+ ·04	+ ·53	+ ·19	− ·02	23·84	45 05·22	·62	− ·04
	46.....	52 03·36	·02	− ·17	+ ·45	+ ·14	− ·02	03·74	51 45·07	·67	− 09
	ε Arietis.... ...	54 02·82	− ·02	·40	+ ·47	+ ·12	− ·02	02·97	53 44·40	·57	− ·01
	47...............	57 34·87	·02	− ·27	+ ·44	+ ·10	− ·02	35·10	57 16·54	·56	·02
	μ Horologii......	3 01 39·45	− ·03	+ ·51	+ ·89	+ ·07	− ·04	40·85	3 01 22·40	·45	·13
E	549..............	08 19·59	+ ·02	·00	− ·51	+ ·02	− ·02	19·10	07 60·44	·66	+ ·08
	53.............	19 59·23	+ ·02	·31	− ·45	− ·06	− ·02	58·41	19 39·83	·58	·00
	55..............	25 54·88	+ ·01	− ·33	− ·45	− ·11	− ·02	53·98	25 35·39	·59	− ·01
	B.A.C. 1106.....	30 03·49	+ ·03	+ ·29	− ·70	− ·15	− ·03	02·93	29 44·24	·69	+ ·11
	10 Taureau.....	32 18·75	+ ·02	·24	− ·44	− ·17	− ·02	17·90	31 59·45	·45	·13
	550..............	38 59·22	+ ·02	− ·16	·45	− ·21	− ·02	58·40	38 39·98	·42	− ·16

$a = +^s{\cdot}492$ $c = -^s{\cdot}443$

Chronometer correction at $3^h\ 10^m = -18^s{\cdot}580 \pm {}^s{\cdot}021$

TRANSIT OBSERVATIONS.

Station : Norfolk Island. Date, December 9th, 1903. Observer : F. W. O. Werry.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s,	s. r = − ·29	s.		h. m. s.	s.	s.
E	47........	2 58 02·16	− ·02	− ·24	− ·53	+ ·14	·02	01·49	2 57 16 54	−44·95	+ ·07
	α Horologii....	3 02 07 68	− ·03	+ ·47	−1·06	+ ·13	− ·04	07·15	3 01 22·32	·83	− ·05
	359..............	06 55 19	− ·01	− ·36	− ·56	·10	− ·02	54 34	06 09·41	·93	+ ·05
	549...........	08 45 70	− ·02	·00	− ·61	+ ·09	− ·02	45·20	08 00·43	·77	·11
	ζ Arietis........	10 09 92	− ·01	·37	− ·56	+ ·09	− ·02	09·05	09 24 10	·95	+ ·07
	ε Eridani	16 52 12	− ·02	+ ·15	− ·73	+ ·06	− ·03	51·55	16 06 68	·87	01
	53............	20 25 52	− ·02	− ·28	− ·53	+ ·04	− ·02	24·71	19 39 81	·90	+ 02
	54..............	22 44 72	− ·02	− ·29	− ·53	+ ·03	− ·02	43·89	21 59·01	·88	·00
W	55.	26 20·16	− ·08	− ·31	+ 54	·02	− ·02	20·31	25 35·39	·92	+ ·04
	B.A.C. 1106. ..	30 28 22	− ·16	+ ·26	+ ·83	·00	− ·03	29 12	29 44·21	·91	+ ·03
	10 Taureau	32 44 09	− ·09	− ·22	+ ·53	·01	− ·02	44·28	31 59·45	·83	− ·05
	61...........	42 32·75	− ·07	− ·39	+ ·57	− ·06	− ·02	32·78	41 47·85	·93	− ·05
	g Eridani.......	46 37 22	− ·13	+ ·07	+ ·65	·07	− ·03	37·71	45 52·91	·80	− ·08
	552..............	54 18 70	− ·11	− ·12	− ·44	− 10	− .02	18 79	53 34·02	·77	− ·11

a = + ·453 c = − ·527

Chronometer correction at $3^h\,30^m = -44^s\cdot876 \pm {}^s\cdot012$

TRANSIT OBSERVATIONS.

Station : NORFOLK ISLAND. Date, December 10th, 1903. Observer : F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − 23	s.		h. m. s.	s.	s.
E	ζ^1 Piscium.....	1 09 35·22	+ ·01	− ·32	− ·49	+ ·12	·02	34·52	1 08 43·42	−51·10	− ·01
	γ Phœnicis......	25 03·61	+ ·01	− ·19	− ·67	+ ·05	·03	03·16	24 12·10	·06	·03
	22.............	27 13·40	+ ·01	− ·38	− ·50	+ ·05	·02	12·56	26 21·40	·16	+ ·07
	ν Piscium.......	37 18·62	+ ·01	− ·32	− ·48	+ ·01	·02	17·82	36 26·74	·08	·01
	542............	40 28·68	+ ·01	− ·12	− ·50	·00	·02	28·05	39 36·97	·08	·01
	25............	41 12·03	+ ·01	− ·33	− ·49	·00	·02	11·20	40 20·07	·13	− ·04
	543...........	42 01·04	+ ·01	− ·04	− ·54	·01	·02	00·14	41 09·37	·07	·02
W	χ Baleine......	45 43·52	·06	·17	+ ·49	·02	·02	43·74	44 52·72	·02	·07
	544...........	47 34·62	− ·06	·17	+ ·49	·02	·02	34·84	46 43·83	·01	·08
	ψ Phœnicis.....	50 38·68	·09	+ ·24	+ ·71	·04	·03	39·47	49 48·25	·22	·13
	545............	56 20·14	·06	− ·08	+ ·52	·06	·02	20·44	55 29·43	·01	·08
	33...........	2 02 37·79	·04	− ·45	+ ·52	·08	·02	37·72	2 01 46·57	·15	− ·06

$a = +^{s}·538 \qquad c = -^{s}·483$

Chronometer correction at $1^h\ 40^m = -51^s·089 \pm {}^{s}·016$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	39..............	2 35 25·63	− ·05	·27	+ ·52	+ ·09	− ·02	25·90	2 34 34·48	−51·42	+ ·03
	41............	39 11·56	− ·05	·30	+ ·52	+ ·07	− ·02	11·78	38 20·42	·36	·03
	547.............	40 25·03	− ·05	·14	+ ·54	+ ·07	− ·02	25·43	39 33·95	·48	+ ·09
	β Fornacis.....	45 56·06	− ·06	+ ·04	+ ·62	·05	− ·02	56·69	45 05·19	·50	+ ·11
	46.............	52 36·16	− ·05	− ·19	− ·53	·03	− ·02	36·46	51 45·06	·40	+ ·01
	θ Eridani.......	55 28·87	− ·06	+ ·15	·69	·02	− ·02	29·65	54 38·31	·34	·05
	τ^3 Eridani.......	59 01·25	− ·05	− ·05	·57	·00	− ·02	01·70	58 10·44	·26	− ·13
E	359............	3 07 01·88	+ ·01	·41	− ·55	·03	− ·02	00·88	3 06 09·41	·47	+ ·08
	549.............	08 52·36	+ ·02	+ ·01	·60	·03	− ·02	51·74	08 00·43	·31	·08
	ζ Arietis........	10 16·52	+ ·01	− ·46	·56	·04	− ·02	15·45	09 24·10	·35	·04
	ι Eridani......	16 58·67	+ ·02	+ ·19	·72	·06	− ·03	58·07	16 06·68	·39	·00
	53............	20 32·17	+ ·01	− ·35	·53	·07	− ·02	31·21	19 39·81	·40	+ ·01
	55.............	26 27·82	+ ·01	− ·38	− ·53	− ·09	− ·02	26·81	25 35·40	·41	+ ·02
	B.A.C. 1106.....	30 36·27	+ ·02	+ ·32	·83	·11	− ·03	35·64	29 44.21	·43	+ ·04

$a = +^{s}·557 \qquad c = -^{s}·523$

Chronometer correction at $3^h\ 00^m = -51^s·393 \pm {}^{s}·013$

TRANSIT OBSERVATIONS.

Station: NORFOLK ISLAND. Date, December 11th, 1903. Observer: F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·26	s.		h. m. s.	s.	s.
E	21	1 20 11·81	+·02	−·21	−·46	+·13	−·02	11·27	1 19 13·90	−57·37	+·01
	γ Phœnicis	25 09·80	+·03	+·21	·63	+·11	−·03	09·49	24 12·08	·41	+·05
	22	27 19·52	+·01	−·43	−·47	+·10	−·02	18·71	26 21·39	·32	−·04
	α Eridani	35 06·20	+·04	+·55	−·85	+·06	−·04	05·96	34 08·72	·24	−·12
	ν Piscium	37 24·82	+·02	−·37	−·45	+·05	−·02	24·05	36 26·73	·32	−·04
	542	40 34·91	+·02	−·14	−·47	+·04	−·02	34·34	39 36·96	·38	+·02
	25	41 18·29	+·02	−·38	−·46	+·04	−·02	17·49	40 20·06	·43	+·07
	543	42 07·28	+·02	−·04	−·50	+·04	−·02	06·78	41 09·36	·42	+·06
W	544	47 40·85	−·02	−·20	+·46	+·01	−·02	41·08	46 43·83	·25	−·11
	ψ Phœnicis	50 44·83	−·03	+·28	+·66	·00	−·03	45·71	49 48·23	·48	+·12
	545	56 26·40	−·02	−·09	+·49	−·03	−·02	26·73	55 29·43	·30	−·06
	33	2 02 43·98	−·02	−·52	+·48	·06	−·02	43·84	2 01 46·56	·28	−·08
	546	09 38·50	−·02	+·02	+·53	·09	−·02	38·92	08 41·41	·51	+·15
	φ Eridani	14 01·73	−·04	+·39	+·73	·11	−·03	02·67	13 05·42	·25	−·11

$a = -\cdot618$ $c = -\cdot450$

Chronometer correction at $1^h\ 50^m = -57^s\cdot355 \pm {}^s\cdot017$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	ε Arietis	2 54 42·09	−·02	·52	−·51	+·11	−·02	42·15	2 53 44·40	−57·75	·00
	47	58 13·98	−·02	·34	+·47	+·10	−·02	14·17	57 16·53	·64	−·11
	μ Horologii	3 02 18·52	·03	−·65	+·95	+·08	−·04	20·13	3 01 22·28	·85	+·10
	359	07 07·17	·01	·50	+·50	+·06	−·02	07·20	06 09·41	·79	+·04
	549	08 57·45	·00	+·01	+·54	+·05	−·02	58·03	08 00·42	·61	·14
	e Eridani	17 03·59	·00	+·21	+·65	+·01	−·03	04·43	16 06·67	·76	+·01
E	53	20 38·41	+·06	·39	·48	·00	−·02	37·58	19 39·81	·77	+·02
	54	22 57·62	+·05	−·40	−·48	·01	−·02	56·76	21 59·01	·75	·00
	55	26 34·15	+·06	·43	−·48	−·03	−·02	33·25	25 35·39	·86	+·11
	B. A. C. 1106	30 42·28	+·10	+·36	·75	−·05	−·03	41·91	29 44·20	·71	−·04
	10 Taureau	32 58·04	−·06	·31	−·47	·06	−·02	57·24	31 59·45	·79	−·04
	550	39 38·39	+·07	−·21	·48	−·09	−·02	37·66	38 39·98	·68	−·07
	551	43 42·44	−·07	−·06	·52	·11	−·02	41·80	42 44·07	·73	−·02

$a = -\cdot629$ $c = -\cdot473$

Chronometer correction at $3^h\ 20^m = -57^s\cdot749 \pm {}^s\cdot015$

TRANSIT OBSERVATIONS.

Station : NORFOLK ISLAND. Date, December 17th. 1903. Observer : F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·27	s.		h. m. s.	m. s.	s.
E	544	1 48 20·71	+ ·13	− ·19	− ·50	+ ·10	− ·02	20·23	1 46 43·78	-1 36·45	·03
	ψ Phœnicis	51 24·84	+ ·19	+ ·28	− ·73	+ ·09	− ·03	24·64	49 48·14	·50	+ ·02
	545	57 06·18	+ ·14	− ·08	− ·52	+ ·06	− ·02	05·76	55 29·37	·39	− ·09
	33	2 03 23·93	+ ·09	− ·51	− ·52	+ ·03	− ·02	23 00	2 01 46 52	·48	00
	546	10 18·39	+ ·16	+ ·02	− ·57	·00	02	17·98	08 41·35	·63	+ ·15
	φ Eridani.	14 42·03	+ ·20	+ ·38	− ·78	− ·02	− ·03	41·78	13 05·33	·45	03
W	δ Hydri	21 37·27	+ ·16	+1·09	− 1 36	·05	− ·05	39·78	20 03·30	·48	·09
	37	24 40·37	+ ·06	·37	+ ·49	·07	− ·02	40·46	23 04·05	·41	− ·07
	ν Ceti	32 27·32	+ ·07	− ·24	+ ·49	·10	− ·02	27·52	30 50·96	·56	+ ·08
	355	34 59·44	+ ·05	− ·50	+ ·52	·11	·02	59·38	33 22·85	·53	+ ·05
	39	36 10·89	+ ·07	·29	+ ·49	·12	− ·02	11·02	34 34 45	·57	+ ·09
	41	39 56·70	+ ·07	− ·32	+ ·49	·13	− ·02	56·79	38 20·39	·40	− ·08
	547	41 10·09	+ ·08	− ·16	+ ·50	− ·14	− ·02	10·35	39 33·91	·44	− ·04

$a = -^{s}\cdot603$ $c = -^{s}\cdot486$

Chronometer correction at $2^{h}\ 10^{m} = -1^{m}36^{s}\cdot485 \pm {}^{s}\cdot015$

TRANSIT OBSERVATIONS.

Station : NORFOLK ISLAND. Date, December 18th, 1903. Observer : F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·27	s.		h. m. s.	m. s.	s.
E	α Hydri	1 57 28·73	+ ·15	+ ·59	1·27	+ ·28	− ·04	28 44	1 55 41·84	-1 43·60	+ ·11
	353	2 13 56·27	+ ·08	− ·19	·60	+ ·20	− ·02	55·74	2 12 12·31	·43	− ·06
	κ Fornacis	19 53·48	+ ·07	− ·05	·65	+ ·18	− ·02	53·01	18 09·58	·43	− ·06
	σ Baleine	29 15·73	+ ·09	− ·12	− ·62	− ·14	− ·02	16·20	27 32·88	·32	− ·17
	355.	35 07·31	+ ·05	− ·41	− ·64	+ ·11	·02	06·40	33 22·84	·56	+ ·07
W	54	3 23 42·26	+ ·04	− ·32	+ 60	·11	− ·02	42·45	3 21 59·01	·44	− ·05
	B.A.C. 1106	31 26·49	+ ·08	+ ·29	+ ·94	− ·14	− ·03	27·63	29 44·12	·51	+ ·02
	550	40 23·22	+ ·05	− ·17	+ ·60	18	− ·02	23·50	38 39·99	·51	+ ·02
	61	43 31·42	+ ·03	− ·44	+ ·65	·20	− ·02	31·44	41 47·87	·57	+ ·08
	552	55 17·26	+ ·05	− ·14	+ ·61	− ·25	− ·02	17 51	53 34·04	·47	− ·02
	66	57 06·32	+ 04	− ·34	+ ·61	26	− ·02	06·35	55 22·80	·55	+ ·06
	δ Réticule	58 57·09	+ ·09	+ ·58	+1·25	− ·27	− ·04	58·70	57 15·27	·43	− ·06

$a = +^{s}\cdot505$ $c = -^{s}\cdot594$

Chronometer correction at $3^{h}\ 00^{m} = -1^{m}\ 43^{s}\cdot486 \pm {}^{s}\cdot016$

TRANSIT OBSERVATIONS.

Station: NORFOLK ISLAND. Date, December 19th, 1903. Observer: F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − 25	s.		h. m. s.	m. s.	s.
W	21............ ...	1 21 03·22	+ ·05	− ·18	+ ·55	+ ·16	− ·02	03 78	1 19 13 82	−1 49·96	− ·03
	22.............	28 10 95	+ ·04	− ·37	+ ·56	13	− ·02	11·29	26 21·32	·97	− ·02
	α Eridani.......	35 56·79	+ ·09	+ ·48	+1·02	·10	− ·04	58·44	34 08 51	·93	− ·06
	ν Piscium......	38 16 37	+ ·64	− ·32	+ ·55	+ ·09	− ·02	16·71	36 26·67	50·04	+ ·05
	542......	41 26 34	+ ·06	− ·12	+ ·57	+ ·08	− ·02	26 91	39 36·88	·03	+ ·04
	25	42 00·70	+ ·05	− ·33	+ ·55	+ ·07	− ·02	10·02	40 20·00	·02	+ ·03
E	α Hydri.	57 35 17	+ ·24	+ ·61	−1·16	+ ·01	− ·04	34·83	55 44·80	·03	+ ·04
	37..	2 24 54 85	+ ·11	− ·32	− ·55	10	− ·02	53·97	2 22 64·03	49·94	− ·05
	σ Baleine.	29 23 45	+ ·14	− ·13	− ·57	·12	− ·02	22·75	27 32 87	·88	− ·11
	ν Ceti..........	32 41 85	+ ·13	− ·21	− ·55	13	− ·02	41·07	30 50 94	50·13	+ ·14
	355....... ...	35 13·82	+ ·10	− ·43	− ·58	15	− ·02	12·74	33 22·83	49·91	− ·08
	39	36 25 26	+ ·12	− ·25	− ·55	·15	− ·02	24·41	34 34·45	·96	− ·03
	41..............	40 11·30	+ ·12	− ·28	− ·55	·17	− ·02	10·40	38 20 38	50·02	+ ·03

$a = -{}^{s}·528 \quad c = -{}^{s}·546$

Chronometer correction at $2^{h}\ 00^{m} = -1^{m}\ 49^{s}·986 \pm {}^{s}·015$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
E	53	3 21 30·95	− 06	− ·34	− ·49	− ·12	− ·02	30·28	3 19 39·80	−1 50·48	+ ·04
	54	23 50·13	− ·06	− ·35	·49	+ ·11	− ·02	49·44	21 59·00	·44	·00
	55.....	27 26 59	− 06	− ·38	− ·50	+ ·10	− ·02	25·85	25 35·39	·46	+ ·02
	10 Taureau......	33 50·57	− 07	− ·27	− ·49	+ 07	− ·02	49 93	31 59·45	·48	+ ·04
	550.	40 30 93	+ 08	− ·18	− ·50	+ ·04	− ·02	30 35	38 39·98	·37	·07
	551.......	44 34 98	+ 09	− ·06	− ·53	+ ·02	− ·02	34·48	42 44·06	·42	·02
W	552.............	55 24·26	+ ·01	− ·15	+ ·50	·02	− ·02	24·58	53 34·03	·55	+ ·11
	66.:...........	57 13 13	+ ·01	− ·37	+ ·50	− ·03	− ·02	13·22	55 22 80	·42	·02
	366....	4 09 02·13	+ 01	− ·33	+ ·49	08	− ·02	02·20	4 07 11·83	·37	·07
	α Horologii ...	12 40 25	+ 04	− ·18	+ ·66	·09	− ·03	41·01	10 50 60	·41	− 03
	71...............	19 15 62	− ·01	− ·42	+ ·51	− ·12	− ·02	15·58	17 25·12	·46	+ ·02
	d Eridani	22 17 08	− 03	+ ·06	+ ·59	− ·13	− ·02	17·61	20 27·14	·47	+ ·03

$a = +{}^{s}·556 \quad c = -{}^{s}·488$

Chronometer correction at $3^{h}\ 50^{m} = -1^{m}\ 50^{s}·444 \pm {}^{s}·018$

TRANSIT OBSERVATIONS.

Station : DOUBTLESS BAY. Date, December 5th, 1903. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·49	s.		h. m. s.	s.	s.
E	ω Piscium	23 54 39·77	− ·01	− ·30	− ·41	+ ·42	− ·02	39·45	23 54 23·07	−16·38	+ ·01
	2 Ceti	59 05·89	− ·02	− ·14	− ·42	+ ·36	− ·02	05·65	58 49·32	·33	− ·04
	γ Pegasi	24 08 34·73	− ·01	− ·35	− ·42	+ ·30	− ·02	34·23	24 08 17·86	·37	·00
	ζ Toucani	15 20·54	− ·04	+ ·55	− ·97	+ ·25	− ·04	20·29	15 04·01	·28	− ·09
	β Hydri	20 58·90	− ·06	+1·44	−1·91	+ ·20	− ·08	58·49	20 42·09	·40	+ ·03
	12 Ceti	25 25·56	− ·01	− ·23	− ·40	+ ·16	− ·02	25·06	25 08·63	·43	+ ·06
	β Ceti	39 03.40	− ·01	− ·13	− ·42	+ ·05	− ·02	02·87	38 46·45	·42	+ ·05
W	α Sculptoris	54 15·46	− ·36	− ·04	+ ·46	− ·07	− ·02	15·43	53 59·00	·43	+ ·06
	ε Piscium	58 14·76	− ·23	− ·30	+ ·41	− ·11	− ·02	14·51	57 58·14	·37	·00
	β Phœnicis	25 02 04·41	− ·45	+ ·14	+ ·59	− ·14	− ·02	04·53	25 01 48·15	·38	+ ·01
	θ Ceti	19 30·69	− ·30	− ·20	+ ·41	− ·28	− ·02	30·30	19 13·97	·33	− ·04
	γ Phœnicis	24 28·65	− ·43	+ ·09	+ ·56	− ·32	− ·02	28·53	24 12·18	·35	− ·02
	η Piscium	26 38·29	− ·21	− ·35	+ ·42	− ·33	− ·02	37·80	26 21·47	·33	− ·04
	α Eridani	34 25·20	− ·54	+ ·32	+ ·75	− ·42	− ·03	25·28	34 08·89	·39	+ ·02

$a = +^{s}\cdot448 \qquad c = -^{s}\cdot403$

Chronometer correction at $24^{h}\ 45^{m} = -16^{s}\cdot371 \pm {}^{s}\cdot009$

TRANSIT OBSERVATIONS.

Station : DOUBTLESS BAY. Date, December 6th, 1903. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·49	s.		h. m. s.	s.	s.
E	2 Ceti	23 59 19·81	+ ·17	− ·14	− ·51	+ ·44	− ·02	19·75	23 58 49·31	−30·44	− ·05
	γ Pegasi	24 08 48·70	+ ·11	− ·35	− ·50	+ ·35	·02	48·29	24 08 17·86	·43	− ·06
	ι Ceti	15 03·09	+ ·15	− ·19	− ·49	+ ·31	− ·02	02·85	14 32·32	·53	+ ·04
	β Hydri	21 12·57	+ ·59	+1·43	−2·31	+ ·26	− ·08	12·46	20 42·00	·46	− ·03
	β Ceti	39 17·36	+ ·17	− ·13	− ·51	+ ·11	− ·02	16·98	38 46·46	·52	+ ·03
	δ Piscium	44 13·65	+ ·13	− ·30	− ·50	+ ·07	− ·02	13·03	43 42·50	·53	+ ·04
	20 Ceti	48 37·58	+ ·15	− ·24	− ·49	+ ·04	− ·02	37·02	48 06·47	·55	+ ·06
W	α Sculptoris	54 29·30	− ·23	− ·05	+ ·56	− ·01	− ·02	29·55	53 58·99	·56	+ ·07
	ε Piscium	58 28 64	− ·15	− ·30	+ ·49	− ·04	− ·02	28·62	57 58·13	·49	·00
	β Phœnicis	25 02 18·21	− ·29	+ ·14	+ ·72	− ·07	·02	18 69	25 01 48·13	·56	+ ·07
	ζ¹ Piscium	09 13·98	− ·15	− ·30	+ ·49	− ·13	− ·02	13·87	08 43·45	·42	− ·07
	α Eridani	34 38·81	− ·34	+ ·32	+ ·91	− ·33	− ·04	39·33	34 08·87	·46	− ·03
	ο Piscium	40 50·93	− ·15	− ·31	+ ·49	− ·38	− ·02	50·56	40 20 12	·44	− ·05
	ζ Ceti	47 14·66	− ·19	− ·19	+ ·50	− ·44	− ·02	14·32	46 43·92	·40	− ·09

$a = +^{s}\cdot445 \qquad c = -^{s}\cdot488$

Chronometer correction at $24^{h}\ 53^{m} = -30^{s}\cdot486 \pm {}^{s}\cdot011$

TRANSIT OBSERVATIONS.

Station : DOUBTLESS BAY. Date, December 7th, 1903. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·44	s.		h. m. s.	s.	s.
E	β Hydri........	0 21 25·08	+ ·41	+1·23	−1·93	+ ·29	− ·08	25·00	0 20 41·91	−43·09	·00
	12 Ceti..........	25 51·92	+ ·10	− ·20	− ·41	+ ·26	− ·02	51·65	25 08·60	·05	− ·04
	β Ceti..........	39 29·73	+ ·12	− ·11	− ·43	+ ·16	− ·02	29·45	38 46·45	·00	− ·09
	δ Piscium........	44 26·10	+ ·09	− ·26	− ·41	+ ·12	− ·02	25·62	43 42·49	·13	+ ·04
	20 Ceti..........	48 49·97	+ ·10	− ·21	− ·41	− ·09	− ·02	49·52	48 06·46	·06	− ·03
	α Sculptoris.....	54 42·45	+ ·14	− ·04	− ·47	− ·05	− ·02	42·11	53 58·98	·13	+ ·04
	ε Piscium........	58 41·84	+ ·09	− ·26	− ·41	+ ·02	− ·02	41·26	57 58·12	·14	+ ·05
W	ζ¹ Piscium.......	1 09 26·60	− ·15	− ·26	+ ·41	− ·06	− ·02	26·52	1 08 43·44	·08	− ·01
	θ Ceti...........	19 57·13	− ·18	− ·17	+ ·41	− ·13	− ·02	57·04	19 13·95	·09	·00
	γ Phœnicis.......	24 55·12	− ·27	+ ·08	+ ·57	− ·17	− ·02	55·31	24 12·15	·16	+ ·07
	η Piscium........	27 04·75	− ·13	− ·30	+ ·42	− ·19	− ·02	04·53	26 21·44	·09	·00
	α Eridani........	34 51·47	− ·34	+ ·28	+ ·76	− ·24	− ·04	51·89	34 08·84	·05	− ·04
	ν Piscium........	37 10·14	− ·15	− ·25	+ ·41	− ·26	− ·02	09·87	36 26·75	·12	+ ·03
	ο Piscium........	41 03·52	− ·15	− ·27	+ ·41	− ·29	− ·02	03·20	40 20·11	·09	·00

$a = +^{s}\cdot383$ $c = -^{s}\cdot407$

Chronometer correction at $1^h\ 01^m = -43^s\cdot091 \pm {}^s\cdot009$

TRANSIT OBSERVATIONS.

Station : DOUBTLESS BAY. Date, December 9th, 1903. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·42	s.		h. m. s.	m. s.	s.
E	β Ceti...........	0 39 52·42	− ·13	− ·15	− ·47	+ ·57	− ·02	52·48	0 38 46·42	−1 06.06	− ·10
	δ Piscium........	44 48·76	+ ·10	− ·33	− ·45	+ ·52	− ·02	48·58	43 42·47	·11	− ·05
	α Sculptoris.....	55 05·17	+ ·15	− ·05	− ·51	+ ·45	− ·02	05·19	53 58·95	·24	+ ·08
	β Phœnicis.......	1 02 54·22	+ ·18	+ ·15	− ·66	+ ·41	− ·02	54·28	1 01 48·07	·21	+ ·05
	α Eridani........	35 15·11	+ ·22	+ ·35	− ·84	− ·17	− ·03	14·98	34 08·79	·19	+ ·03
	ο Piscium........	41 26·76	+ ·09	− ·34	− ·45	− ·13	− ·02	26·17	40 20·10	·07	− ·09
W	κ Fornacis.......	2 19 15·74	− ·16	− ·10	+ ·49	− ·13	− ·02	15·82	2 18 09·66	·16	·00
	δ Hydri..........	21 08·25	− ·35	+ ·77	+1·25	·15	− ·05	09·72	20 03·63	·09	− ·07
	ξ² Ceti..........	24 10·41	·11	·33	− ·45	− ·17	− ·02	10·23	23 04·10	·13	− ·03
	θ Eridani........	55 44·48	·18	+ ·06	·59	− ·39	− ·02	44·54	54 38·32	·22	− ·06
	α Ceti...........	58 23·28	− ·11	− ·31	+ ·45	·41	− ·02	22·88	57 16·59	·29	+ ·13
	ο Tauri..........	3 20 46·60	·11	·34	+ ·45	·57	− ·02	46·01	3 19 39·82	·19	− ·03

$a = +^{s}\cdot489$ $c = -^{s}\cdot446$

Chronometer correction at $2^h\ 00^m = -1^m\ 06^s\cdot164 \pm {}^s\cdot016$

TRANSIT OBSERVATIONS.

Station : DOUBTLESS BAY. Date, December 10th, 1903. OBSERVER : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·42	s.		h. m. s.	m. s.	s.
E	β Hydri	0 21 59·41	+ ·45	+1·06	−1·83	+ 31	− ·08	59·32	0 20 41·64	−1 17·68	+ ·02
	β Ceti	40 04·25	+ ·13	− ·10	− ·41	+ ·18	− ·02	04·03	38 46·41	·62	− ·04
	δ Piscium	45 00·54	+ ·10	− ·22	− ·39	+ ·14	− ·02	00·15	43 42·46	·69	+ ·03
	20 Ceti	49 24·44	+ ·11	− ·18	− ·39	+ ·11	− ·02	24·07	48 06·43	·64	− ·02
	α Sculptoris	55 16·88	+ ·15	− ·03	− ·45	+ ·07	− ·02	16·60	53 58·93	·67	+ ·01
	ε Piscium	59 16·23	+ 10	− ·22	− ·39	+ ·04	− ·02	15·74	57 58·09	·65	− ·01
	β Phœnicis	1 03 05·95	+ ·18	+ ·10	− ·57	+ ·01	− ·02	05·65	1 01 48·05	·60	− ·06
W	θ Ceti	20 31·60	− ·13	− ·15	+ ·39	− ·10	− ·02	31·59	19 13·93	·66	·00
	γ Phœnicis	25 29·52	− ·19	+ ·07	+ ·54	− ·15	− 02	29·77	24 12·10	·67	+ ·01
	η Piscium	27 39·23	− ·10	− ·26	+ ·40	− ·15	− ·03	39·09	26 21·43	·66	·00
	α Eridani	35 25·94	− ·26	+ ·24	+ ·72	− ·21	− ·02	26·41	34 08·76	·65	·01
	ν Piscium	37 44·57	− ·10	− ·21	+ ·39	− ·22	− ·02	44·41	36 26·75	·66	·00
	ζ Ceti	48 01·73	− ·14	− ·14	+ ·39	− ·30	− ·02	01·52	46 43·89	·63	− ·03
	β Arietis	50 39·01	− ·09	− ·29	+ ·41	− ·31	− ·02	38·71	49 21·01	·70	+ ·04

$a = +^{s}\cdot330 \qquad c = -^{s}\cdot387$

Chronometer correction at $1^{h}\ 05^{m} = -1^{m}\ 17^{s}\cdot657 \pm {}^{s}\cdot005$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	σ Arietis	2 47 30·97	− ·13	− ·32	+ ·41	+ ·34	− ·02	31·25	2 46 12·49	−1 18·76	+ ·08
	θ Eridani	55 56·23	·25	+ ·05	+ ·52	+ ·29	·02	56·82	54 38·30	·52	− ·16
	α Ceti	58 35·05	− ·15	− ·25	+ ·40	+ ·27	− ·02	35·30	57 16·58	·72	+ ·04
	μ Horologii	3 02 40·04	− ·34	+ ·34	+ ·79	+ ·24	− ·04	41·03	3 01 22·30	·73	+ ·05
	ο Tauri	20 58·48	− ·14	− ·28	+ ·40	+ ·11	− ·02	58·55	19 39·82	·73	+ ·05
	ε Eridani	29 44·01	− ·17	·17	+ ·40	+ ·05	− ·02	44·10	28 25·41	·69	+ ·01
E	δ Eridani	39 59·19	+ ·08	− ·17	− ·40	·02	− ·02	58·66	38 39·98	·68	·00
	γ Hydri	50 05·76	+ ·26	+ ·97	−1·48	− ·10	− ·07	05·34	48 46·64	·70	+ ·02
	γ¹ Eridani	54 53·36	+ ·10	− ·15	− ·41	− ·13	− ·02	52·75	53 34·05	·70	+ ·02
	A¹ Tauri	4 00 22·01	+ ·05	− ·36	− ·43	·17	− ·02	21·08	59 02·41	·67	− ·01
	o¹ Eridani	08 31·21	+ ·08	− ·19	− ·40	− ·22	− ·02	30·46	4 07 11·82	·64	·04
	ε Tauri	24 21·64	+ ·06	− ·35	·42	− ·34	− ·02	20·57	22 61·89	·68	·00

$a = +^{s}\cdot405 \qquad c = -^{s}\cdot395$

Chronometer correction at $3^{h}\ 36^{m} = -1^{m}\ 18^{s}\cdot683 \pm {}^{s}\cdot013$

TRANSIT OBSERVATIONS.

Station: DOUBTLESS BAY. Date, December 11th, 1903. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·40	s.		h. m. s.	m. s.	s.
E	ι Ceti	0 16 00 99	+ ·26	− ·15	− ·36	+ ·27	− ·02	00·99	0 14 32·27	-1 28·72	·00
	β Hydri	22 09·74	+ ·99	+1·10	−1·70	+ ·23	− ·08	10·28	20 41 55	·73	+ ·01
	12 Ceti	26 37·31	+ ·25	− ·17	− ·36	+ ·21	− ·02	37·22	25 08·56	·66	− ·06
	β Ceti	40 15·16	+ ·29	− ·10	− ·38	+ ·11	− ·02	15·06	38 46·40	·66	− ·06
	δ Piscium	45 11·54	+ ·21	− ·23	− ·36	+ ·08	− ·02	11·22	43 42·45	·77	+ ·05
	α Sculptoris	55 27·81	+ ·33	− ·03	− ·41	+ ·02	− ·02	27·70	53 58·92	·78	+ ·06
	ε Piscium	59 27·30	+ ·21	− ·23	− ·36	− ·02	− ·02	26·88	57 58·08	·80	+ ·08
W	β Phœnicis	1 03 16·10	+ ·06	+ ·11	+ ·53	·04	− ·03	16·73	1 01 48·03	·70	− ·02
	ζ¹ Piscium	10 12·06	+ ·03	− ·23	+ ·36	− ·09	− ·02	12·11	08 43·41	·70	− ·02
	θ Ceti	20 42·61	+ ·03	·15	+ ·36	− ·15	− ·02	42·68	19 13·91	77	+ ·05
	γ Phœnicis	25 40·45	+ ·05	+ ·07	+ ·50	− ·18	− ·02	40·87	24 12·08	·79	+ ·07
	η Piscium	27 50·25	+ ·02	− ·27	+ ·37	− ·20	− ·02	50·15	26 21·42	·73	+ ·01
	α Eridani	35 36·74	− ·06	+ ·25	+ ·67	− ·26	− ·04	37·42	34 08·73	·69	− ·03
	ν Piscium	37 55·51	+ ·03	− ·22	+ ·36	− ·27	− ·02	55·39	36 26·72	·67	− ·05

$a = +^{s}\cdot341 \qquad c = -^{s}\cdot360$

Chronometer correction at $0^h\ 57^m = -1^m\ 28^s\cdot725 \pm {}^s\cdot010$

TRANSIT OBSERVATIONS.

Station: Doubtless Bay. Date, December 12th, 1903. Observer: Otto Klotz.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = −·40	s.		h. m. s.	m. s.	s.
E	γ Pegasi	0 09 58·46	+·13	−·27	−·41	+·34	−·02	58·23	0 08 17·88	−1 40·35	−·08
	ι Ceti	16 12·80	+·18	−·15	·40	+·29	−·02	12·70	14 32·25	·45	+·02
	β Hydri	22 21·76	+·69	+1·13	−1·88	+·25	−·08	21·87	20 41·45	·42	−·01
	12 Ceti	26 49·19	+·17	−·18	−·40	+·22	−·02	48·98	25 08·55	·43	·00
	β Ceti	40 26·98	+·20	−·11	−·42	+·13	−·02	26·76	38 46·39	·37	−·06
	δ Piscium	45 23·36	+·15	−·24	−·40	+ 10	−·02	22·95	43 42·44	·51	+·08
	α Sculptoris	55 39·65	+·23	−·04	−·46	+·02	−·02	39·38	53 58·91	·47	+·04
W	β Phœnicis	1 03 28·01	−·16	+·11	+·59	−·02	−·03	28·50	1 01 48·00	·50	+·07
	ζ¹ Piscium	10 23·82	−·09	−·23	+·40	−·07	−·02	23·81	08 43·39	·42	·01
	γ Phœnicis	25 52·23	−·16	+·07	+·55	−·18	−·02	52·49	24 12·06	·43	·00
	η Piscium	28 01·97	−·08	·28	+·41	−·19	−·02	01·81	26 21·40	·41	−·02
	α Eridani	35 48·61	−·20	+·25	+·74	−·24	−·04	49·12	34 08·71	·41	−·02
	ν Piscium	38 07·31	−·09	−·22	+·40	−·26	−·02	07·12	36 26·71	·41	−·02
	ζ Ceti	48 24·46	−·11	−·15	+·41	−·34	−·02	24·25	46 43·87	·38	−·05

$a = +^{s}\cdot350$ $c = -^{s}\cdot398$

Chronometer correction at $0^h\ 59^m = -1^m\ 40^s\cdot426 \pm {}^{s}\cdot009$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	μ Horologii	3 03 02·71	−·42	+·34	+·92	+·31	−·03	03·83	3 01 22·26	−1 41·57	+·02
	δ Arietis	08 50·73	·14	−·35	+·49	+·27	−·02	50·98	06 09·43	·55	·00
	τ¹ Arietis	17 23·52	−·14	−·35	+·49	+·22	−·02	23·72	15 42·18	·54	−·01
	f Tauri	27 16·81	−·16	−·30	+·47	+·15	−·02	16·95	25 35·41	·54	−·01
	ε Eridani	30 06·70	−·21	−·17	+·46	+·13	−·02	06·89	28 25·41	·48	−·07
	τ⁵ Eridani	31 15·07	−·24	−·10	+·50	+·12	−·02	15·33	29 33·76	·57	+ 02
	η Tauri	43 29·48	−·13	−·37	+·50	+·04	·02	29·50	41 47·90	·60	+·05
E	A¹ Tauri	4 00 44·79	+·09	−·36	−·50	−·07	−·02	43·93	59 02·42	·51	−·04
	ω¹ Tauri	05 18·08	+·08	−·35	−·49	−·10	·02	17·20	4 03 35·58	·62	+·07
	o¹ Eridani	08 53·99	+·13	−·18	−·46	−·13	−·02	53·33	07 11·82	·51	−·04
	α Reticuli	14 55·45	+·29	+·41	−1·00	−·17	−·04	54·94	13 13·36	·58	+·03
	ε Tauri	24 44·46	+·09	−·35	·49	−·23	−·02	43·46	23 01·90	·56	+·01
	α Tauri	32 08·47	+·10	−·33	−·48	−·29	−·02	07·45	30 25·95	·50	−·05
	53 Eridani	35 30·51	+·15	−·14	−·47	−·31	−·02	29·72	33 48·13	·59	+·04

$a = +^{s}\cdot402$ $c = -^{s}\cdot460$

Chronometer correction at $3^h\ 49^m = -1^m\ 41^s\cdot551 \pm {}^{s}.010$

TRANSIT OBSERVATIONS.

Station: DOUBTLESS BAY. Date, December 17th, 1903. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·33	s.		h. m. s.	m. s.	s.
E	β Hydri........	0 23 19·89	+ ·42	+1·00	−1·74	+ ·30	− ·08	19·79	0 20 40·98	−2 38·81	− ·07
	δ Piscium......	46 21·68	+ ·10	− ·21	− 37	+ ·18	− ·02	21·36	43 42·39	·97	+ ·09
	α Sculptoris....	56 37·93	+ ·14	− ·03	− ·42	+ ·13	− ·02	37·73	53 58·84	·89	+ ·01
	ε Piscium......	1 00 37·40	+ ·10	·21	− ·37	+ ·10	− ·02	37·00	57 58·03	·97	+ ·09
	β Phœnicis.....	04 27·10	+ ·17	+ ·10	·54	+ ·08	− ·02	26·89	1 01 47·91	·98	+ ·10
	ζ¹ Piscium......	11 22·70	+ ·10	− ·21	− ·37	+ ·04	− ·02	22·24	08 43·35	·89	+ ·01
	θ Ceti..........	21 53·19	+ ·11	− ·14	− ·37	− ·01	− ·02	52·76	19 13·85	·91	+ ·03
W	ο Piscium......	42 58·92	− ·12	·22	+ ·37	− 13	− ·02	58·80	40 20·03	·77	− ·11
	ζ Ceti..........	49 22·64	− ·16	− ·13	+ ·38	− ·17	− ·02	22·54	46 43·83	·71	− ·17
	β Arietis.......	52 00·06	− ·10	− ·27	+ ·39	·18	− ·02	59·88	49 20·96	·92	+ 04
	α Hydri........	58 23·40	− ·32	+ ·30	+ ·79	− 21	− ·04	23·92	55 44·87	39·05	+ ·17
	α Arietis......	2 04 25·62	− ·10	− ·29	+ ·40	·25	− ·02	25·36	2 01 46·55	38·81	− ·07
	67 Ceti.........	14 51·42	− ·15	− ·15	+ ·37	− ·30	− ·02	51·17	12 12·33	·84	− ·04
	κ Fornacis.....	20 48·63	− ·18	− ·06	+ ·41	·33	− ·02	48·45	18 09·59	·86	− ·02

$a = +^{s}.310 \qquad c = -^{s}{\cdot}369$

Chronometer correction at $1^{h}\ 19^{m} = -2^{m}\ 38^{s}{\cdot}883 \pm {}^{s}{\cdot}018$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	δ Eridani.......	3 41 19·62	− ·25	·18	+ ·37	+ ·25	− ·02	19·79	3 38 39·98	−2 39·81	− ·07
	γ Hydri........	51 24·65	− ·79	+ ·98	+1·36	+ ·19	− ·06	26·33	48 46·40	·93	− ·05
	γ¹ Eridani......	56 13·85	− ·26	− ·15	+ ·37	+ ·17	− ·02	13·96	53 34·06	·90	+ ·02
	A¹ Tauri........	4 01 42·31	− ·16	− ·37	+ ·39	+ ·14	− ·02	42·29	58 62·44	·85	·03
	ω¹ Tauri........	06 15·50	− ·17	− ·35	+ ·38	+ ·11	− ·02	15·45	4 03 35·60	·85	− ·03
	ο¹ Eridani......	09 51·68	− ·24	− ·19	+ ·37	+ ·09	− ·02	51·69	07 11·84	·85	− ·03
E	α Doradûs......	34 37·41	− ·04	+ ·24	− ·64	− ·04	− ·03	36·90	31 57·17	·73	− ·15
	π¹ Orionis......	47 19·67	− ·02	− ·27	− ·37	− ·12	− ·02	18·87	44 38·92	·95	+ ·07
	ε Leporis......	5 04 05·79	− ·02	− ·09	− ·39	− ·21	− ·02	05·06	5 01 25·12	·94	+ ·06
	β Eridani......	05 49·82	− ·02	− ·20	− ·36	− ·22	− ·02	49·00	03 09·06	·94	+ ·06
	μ Leporis.....	11 19·17	− ·02	− ·13	− ·38	− ·25	− ·02	18·37	08 38·39	·98	− ·10

$a = +^{s}{\cdot}408 \qquad c = -^{s}{\cdot}363$

Chronometer correction at $4^{h}\ 26^{m} = -2^{m}\ 39^{s}{\cdot}885 \pm {}^{s}{\cdot}018$

TRANSIT OBSERVATIONS.

Station: DOUBTLESS BAY. Date, December 18th, 1903. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·37	s.		h. m. s.	m. s.	s.
E	β Hydri........	0 23 29·87	+ ·65	+1·17	−1·76	+ ·27	− ·08	30·12	0 20 40·88	−2 49·24	+ ·01
	β Ceti........ ...	41 35·66	+ ·19	− ·11	− ·39	+ ·15	− ·02	35·48	38 46·31	·17	− ·06
	δ Piscium.....	46 32·00	+ ·14	− ·25	− ·38	+ ·12	− ·02	31·61	43 42·37	·24	+ ·01
	20 Ceti.... ...	50 55·87	+ ·16	− ·20	− ·37	+ ·10	− ·02	55·54	48 06·35	·19	− ·04
	α Sculptoris.. ..	56 48·29	+ ·21	− ·04	·43	+ ·06	− ·02	48·07	53 58·82	·25	+ ·02
	ε Piscium. ...	1 00 47·73	+ ·14	− ·25	− ·38	+ ·04	− ·02	47·26	57 58·01	·25	+ ·02
	ζ¹ Piscium	11 33·17	+ ·14	·24	− ·38	− ·03	− ·02	32·64	1 08 43·36	·28	+ ·05
W	θ Ceti..........	22 03·06	− ·12	− ·16	+ ·37	− ·10	− ·02	03·03	19 13·84	·19	− ·04
	γ Phœnicis....	27 00·90	− ·18	− ·08	+ ·52	− ·13	− ·02	01·17	24 11·95	·22	− ·01
	η Piscium......	29 10·78	− ·09	− 29	+ ·38	− ·14	− ·02	10·62	26 21·35	·27	+ ·04
	α Eridani.....	36 57·29	− ·22	+ ·26	+ ·70	− ·18	− ·03	57·82	34 08·54	·28	+ ·05
	ν Piscium......	39 16·06	− ·10	·23	+ ·37	− ·20	− ·02	15·88	36 26·67	·21	− ·02
	ο Piscium......	43 09·49	− ·09	− ·25	+ ·38	− ·23	− ·02	09·28	40 20·02	·26	+ ·03
	υ Ceti..........	58 18·76	− ·13	− ·09	+ ·40	− ·32	− ·02	18·60	55 29·39	·21	− ·02

$a = -{}^{s}\cdot362$ $c = -{}^{s}\cdot373$

Chronometer correction at $1^{h}\ 06^{m} = -2^{m}\ 49^{s}\cdot234 \pm {}^{s}\cdot007$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	f Tauri.	3 28 25·48	− ·08	− ·27	+ ·43	+ ·25	− ·02	25·79	3 25 35·42	−2 50·37	+ ·01
	ε Eridani	31 15·37	− ·10	− ·15	+ ·42	+ ·23	− ·02	15·75	28 25·40	·35	− ·01
	τ⁵ Eridani... ...	32 23·70	− ·12	·09	+ ·45	+ ·22	− ·02	24·14	29 33·77	·37	+ ·01
	δ Eridani.......	41 29·99	− ·11	·15	+ ·43	+ ·17	− ·02	30·31	38 39·93	·38	+ ·02
	γ Hydri........	51 34·58	·33	+ ·85	+1·56	+ ·11	− ·06	36·71	48 46·36	·35	− ·01
	γ¹ Eridani	56 24·16	− ·11	− ·13	+ ·43	+ ·07	− ·02	24·40	53 34·06	·34	− ·02
E	A¹ Tauri........	4 01 52·75	·07	− ·32	+ ·45	+ ·04	− ·02	52·83	59 02·44	·39	+ ·03
	α Reticuli	16 04·02	− ·35	+ ·36	− ·91	− ·05	− ·04	03·73	4 13 13·29	·44	+ ·08
	ε Tauri..	25 53·03	+ ·11	− ·31	− ·44	− ·10	− ·02	52·27	23 01·93	·34	− ·02
	α Doradûs......	34 47·82	+ ·29	+ ·21	− ·73	− ·16	− ·03	47·40	31 57·16	·24	− ·12
	53 Eridani.....	36 39·12	+ ·17	− ·13	·43	− ·17	− ·02	38·54	33 48·16	·38	+ ·02
	τ Tauri........	39 21·55	+ ·10	− ·32	− ·45	− ·19	− ·02	20·67	36 30·32	·35	− ·01
	μ Eridani... .	43 34·36	+ ·15	− ·19	− ·42	− ·22	− ·02	33·66	40 43·32	·34	− 02
	π¹ Orionis.......	47 30·11	+ ·13	− ·24	− ·42	− ·25	− ·02	29·31	44 38·92	·39	+ ·03

$a = -{}^{s}\cdot356$ $c = -{}^{s}\cdot417$

Chronometer correction at $4^{h}\ 08^{m} = -2^{m}\ 50^{s}\cdot360 \pm {}^{s}\cdot009$

TRANSIT OBSERVATIONS.

Station : Doubtless Bay. Date, December 19th, 1903. Observer : Otto Klotz.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = −·40	s.		h. m. s.	m. s.	s.
E	θ Eridani	2 57 39·41	+·10	+·04	−·54	+·33	−·02	39·32	2 54 38·21	−3 01·11	−·20
	α Ceti	3 00 18·03	+·06	−·18	−·41	+·31	−·02	17·79	57 16·56	·23	−·08
	δ Arietis	09 11·22	+·05	−·24	−·43	+·25	−·02	10·83	3 06 09·43	·40	+·09
	f Tauri	28 37·27	+·06	−·21	−·42	+·13	−·02	36·81	25 35·42	·39	+·08
	ε Eridani	31 27·05	+·07	−·12	−·41	+·11	−·02	26·68	28 25·39	·29	−·02
	τ^5 Eridani	32 35·44	+·08	−·07	−·44	+·10	−·02	35·09	29 33·76	·33	+·02
	δ Eridani	41 41·65	+·07	−·12	−·42	+·04	−·02	41·20	38 39·93	·27	−·04
W	γ Hydri	51 45·88	−·51	+·67	+1·54	−·03	−·06	47·49	48 46·31	·18	−·13
	γ^1 Eridani	56 35·26	−·17	−·10	+·42	−·06	−·02	35·33	53 34·06	·27	−·04
	A^1 Tauri	4 02 03·82	−·10	−·25	+·44	−·10	−·02	03·79	59 02·44	·35	+·04
	ω^1 Tauri	06 37·07	−·11	−·24	+·43	−·13	−·02	37·00	4 03 35·60	·40	+·09
	o^1 Eridani	10 13·21	−·16	−·13	−·41	·15	−·02	13·16	07 11·84	·32	+·01
	ε Tauri	26 03·48	−·11	−·24	−·43	−·26	−·02	03·28	23 01·94	·34	−·03
	53 Eridani	36 49·77	−·17	−·10	+·42	−·33	−·02	49·57	33 48·16	·41	+·10

$a = +^{s}\cdot281$ $c = -^{s}\cdot410$

Chronometer correction at $3^h\ 47^m = -3^m\ 01^s\cdot306 \pm {}^{s}\cdot020$

TRANSIT OBSERVATIONS.

Station: WELLINGTON. Date, December 6th, 1903. Observer: THOS. KING.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = + ·25	s.		h. m. s.	s.	s.
E	δ Piscium.......	0 43 47·32	+ ·20	+ ·39	− ·37	− ·23	− ·02	48·03	0 43 42·50	−5·53	+ ·03
	β Phœnicis	1 01 52·80	+ ·43	− ·08	− ·54	− ·15	− ·02	53·52	1 01 48·13	·39	·11
	ζ¹ Piscium.......	08 48·20	+ ·20	+ ·39	+ ·37	− ·12	− ·02	49·02	08 43·45	·57	+ ·07
	θ Ceti..........	19 18·53	+ ·24	+ ·28	+ ·37	− ·09	− ·02	19·31	19 13·96	·35	− ·15
	η Piscium.	26 26·30	+ ·15	+ ·45	+ ·38	− ·06	− ·02	27·20	26 21·46	·74	+ ·24
	α Eridani.. ...	34 13·44	+ ·53	− ·28	− ·69	− ·01	− ·03	14·34	34 08·87	·47	·03
W	ζ Ceti.	46 49·16	+ ·17	+ ·49	− ·40	+ ·04	− ·02	49·44	46 43·92	·52	+ ·02
	α Hydri....	55 51·32	+ ·66	− ·39	− ·79	+ ·08	− ·03	50·85	55 45·20	·65	+ ·15
	ξ¹ Ceti...........	2 08 00·56	+ ·22	+ ·40	·37	+ ·13	− ·02	00·92	2 07 55·47	·45	− ·05
	κ Fornacis	18 14·79	+ ·36	+ ·17	− ·41	+ ·17	− ·02	15·06	18 09·68	·38	− ·12
	ν Ceti....... ...	30 55·93	+ ·23	+ ·38	− ·37	+ ·22	− ·02	56·37	30 50·99	·38	·12

$a = -^s\cdot522 \qquad c = +^s\cdot370$

Chronometer correction at $1^h\ 37^m = -5^s\cdot496 \pm {}^s\cdot031$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	γ Hydri........	3 48 52·86	+1·25	− ·88	−1·22	− ·22	− ·06	51·73	3 48 46·76	−4 97	+ ·13
	A¹ Tauri.... ..	59 07·09	+ ·18	+ ·49	− ·35	− ·17	− ·02	07·22	59 02·39	·83	− ·01
	o¹ Eridani	4 07 16·49	+ ·31	+ ·29	− ·33	− ·14	− ·02	16·60	4 07 11·80	·80	− ·04
	γ Tauri..	14 25·30	+ ·21	+ ·46	− ·34	− ·11	− ·02	25·50	14 20·95	·55	− ·29
	ε Tauri........	23 06·53	+ ·20	+ ·47	− ·35	− ·07	− ·02	06·76	23 01·86	·90	+ ·06
	α Tauri....... .	30 30·34	+ ·21	+ ·46	·34	− ·04	− ·02	30·61	30 25·91	·70	·14
E	ι Aurigæ.......	50 49·73	+ ·10	+ ·59	+ ·39	+ ·04	− ·02	50·83	50 45·92	·91	+ ·07
	ε Leporis.......	5 01 29·24	+ ·31	+ ·18	+ ·35	+ ·05	− ·02	30·11	5 01 25·04	5·07	+ ·23
	β Orionis.....	10 00·70	+ ·26	+ ·28	+ ·33	+ ·12	− ·02	01·67	09 56·59	·08	+ ·24
	β Doradûs.. ...	32 53·74	+ ·62	− ·40	+ ·71	+ ·22	− ·03	54·86	32 50·29	4·57	·27

$a = -^s\cdot512 \qquad c = +^s\cdot326$

Chronometer correction at $4^h\ 40^m = -4^s\cdot840 \pm {}^s\cdot040$

TRANSIT OBSERVATIONS.

Station : WELLINGTON. Date, December 7th, 1903. Observer : THOS. KING.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·09	s.		h. m. s.	s.	s.
E	η Piscium......	1 26 24·11	+ ·19	+ ·23	+ ·35	− ·07	− ·02	24·79	1 26 21·45	− 3·34	− ·14
	α Eridani...	34 11·04	+ ·60	− ·14	+ ·64	− ·06	− ·03	12 05	34 08·84	·21	− ·01
	β Arietis.......	49 23·46	+ ·18	+ ·25	− ·37	− ·04	·02	24·20	49 21·03	·17	− ·03
	υ Ceti....	55 31·94	+ ·34	+ ·10	− 37	− ·03	− ·02	32·70	55 29.47	·23	+ ·03
	β Trianguli......	2 03 53·33	+ ·10	+ ·31	− ·42	− ·02	− ·02	54·12	2 03 51 01	·11	− ·09
W	ν Ceti.....	30 54·19	+ ·23	+ ·19	− ·34	− ·02	− ·02	54 27	30 50·99	·28	+ ·08
	γ² Ceti	38 23·43	+ ·24	+ ·19	− ·34	− 03	·02	23·53	38 20·43	·10	− ·10
	σ Arietis.....	46 15·54	+ ·19	+ ·23	·35	− ·05	− ·02	15·64	46 12·50	14	− ·06
	ε Arietis.. ...	53 47·56	+ ·17	+ ·25	− ·37	− ·06	·02	47·65	53 44·41	·24	+ ·04
	μ Horologii.....	3 01 25·69	+ ·65	− ·17	− ·69	− ·07	·03	25·52	3 01 22·36	·16	− ·04

$a=-{}^{s}{\cdot}265$ $c=+{}^{s}{\cdot}343$

Chronometer correction at $2^{h}\ 14^{m}=-3^{s}{\cdot}195\pm{}^{s}{\cdot}024$

W	ε Persei........	3 51 29·30	+ ·08	− ·48	− ·39	− ·06	− ·02	29 39	3 51 26 27	−3·12	− ·05
	A¹ Tauri........	59 05·37	+ ·20	− ·36	− ·32	− ·05	− ·02	05·54	59 02·40	·14	·03
	ω¹ Tauri	4 03 38·57	+ ·21	− ·34	− ·32	− ·04	− 02	38 74	4 03 35·56	·18	+ ·01
	α Reticuli......	13 16·82	+ ·82	− ·30	− ·65	− ·03	− ·03	16 63	13 13·41	·22	− ·05
	ε Tauri	23 04·82	+ ·21	+ ·34	− ·32	− ·01	− ·02	05 02	23 01·87	·15	− 02
E	α Doradûs	31 59 42	+ ·58	− ·16	+ ·52	·00	− ·02	60·34	31 57·20	·14	·03
	υ Eridani.......	40 45·70	+ ·27	− ·23	+ ·30	+ ·02	− ·02	46·50	40 43·26	·24	+ ·07
	π¹ Orionis.	44 41·24	+ ·17	− ·28	+ ·30	+ ·02	− ·02	41·99	44 38·85	·14	− ·03
	ι Aurigæ.	50 48 33	+ ·11	+ ·43	+ ·35	+ ·03	− ·02	49·23	50 45·93	·30	+ ·13
	β Orionis. ...	5 09 58·83	+ 29	+ ·21	+ ·30	+ ·06	− ·02	59·67	5 09 56·61	·06	− ·11

$a=-{}^{s}{\cdot}373$ $c=-{}^{s}{\cdot}298$

Chronometer correction at $4^{h}\ 30^{m}=-3^{s}{\cdot}165\pm{}^{s}{\cdot}022$

TRANSIT OBSERVATIONS.

Station : WELLINGTON. Date, December 11th, 1903. Observer : THOS. KING.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = + ·09	s.		h. m. s.	s.	s.
E	α Eridani...	1 34 06·72	+ ·53	− ·10	+ ·55	− ·07	− ·03	07·60	1 34 08·74	+1 14	− ·12
	o Piscium.......	40 18·73	+ ·26	+ ·11	+ ·30	− ·06	− ·02	19·32	40 20·08	0·76	+ ·26
	β Arietis...... .	49 19·40	+ ·15	+ ·18	+ ·31	− ·05	− ·02	19·97	49 21·00	1·03	− ·01
	ξ¹ Ceti........ .	2 07 53·80	+ ·19	+ ·15	+ ·30	− 02	− ·02	54·40	2 07 55·45	1·05	− ·03
W	ν Ceti.	30 49·79	+ ·23	+ ·14	·29	+ ·01	− ·02	49·86	30 50·98	1·12	− ·10
	γ²Ceti..... ...	38 19·30	· 26	+ ·14	− ·29	+ ·02	− ·02	19·41	38 20·42	1·01	+ ·01
	θ Eridani.	54 37·11	+ ·47	·00	·39	− ·05	− ·02	37·22	54 38·29	1·07	− ·05
	μ Horologii... ..	3 01 21·36	·68	− ·13	·59	+ ·06	− ·03	21·35	3 01 22·28	0·93	+ ·09
	δ Arietis.. . .	06 08 26	+ ·19	− ·18	− ·31	+ ·07	− ·02	08 37	06 09·44	1·07	− ·05

$a=-{}^{s}{\cdot}196$ $c=+{}^{s}{\cdot}293.$

Chronometer correction at $2^{h}\ 20^{m}=+1^{s}{\cdot}021\pm{}^{s}{\cdot}031$

TRANSIT OBSERVATIONS.

Station : WELLINGTON. Date, December 12th, 1903. Observer : THOS. KING.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	r.
		h. m. s.	s.	s.	s.	s. r = + ·12	s.		h. m. s.	s.	s.
E	ζ Ceti	1 46 40·04	+ ·20	+ ·16	+ ·27	− ·09	·02	40·56	1 46 43·87	+3·31	+ ·05
	α Hydri	55 41·04	+ ·46	− ·24	+ ·55	− ·07	·03	41·71	55 45·02	·31	+ ·05
	α Arietis.......	2 01 42·53	+ ·11	+ ·31	+ ·28	·06	·02	43·15	2 01 46·59	·44	·08
	67 Ceti	12 08·46	+ ·19	+ ·18	+ ·26	− ·04	− ·02	09 03	12 12·36	·33	+ ·03
	κ Fornacis.	18 05·56	+ ·24	+ ·10	+ ·29	− ·03	− ·02	06·14	18 09·63	·49	− ·13
W	ν Ceti	30 47·44	+ ·24	+ ·23	− ·26	·00	− ·02	47·63	30 50·97	·34	+ ·02
	γ^2 Ceti.........	38 16·89	+ ·25	+ ·22	− ·26	+ ·01	− ·02	17·09	38 20·41	·32	+ ·04
	σ Arietis......	46 08·90	+ ·21	+ ·27	− ·27	+ ·03	− ·02	09·12	46 12·48	·36	·00
	μ Horologii . ..	3 01 18·89	+ ·67	− ·20	− ·52	+ ·06	− ·03	18·87	3 01 22·26	·39	− ·03
	τ^1 Arietis... ...	15 38·57	+ ·17	+ ·30	− ·28	+ ·09	− ·02	38·83	15 42·18	·35	+ ·01

$a = -^{s}\cdot 315 \qquad c = +^{s}\cdot 261$

Chronometer correction at $2^h\ 31^m = +3^s\cdot 362 \pm {}^s\cdot 017$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	r.
W	ε Tauri...... ..	4 22 58·47	− ·21	+ ·15	− ·30	− ·09	− ·02	58·42	4 23 01·90	+3·48	+ ·20
	α Doradûs......	31 53·52	+ ·67	·07	·49	− ·07	− ·03	53·53	31 57·19	·66	+ ·02
	μ Eridani......	40 39·54	+ ·31	+ ·10	− ·28	− ·05	− ·02	39·60	40 43·28	·68	·00
	ι Aurigæ.	50 42·34	+ ·13	+ ·18	− ·33	− ·03	− ·02	42·27	50 45·98	·71	− 03
	ε Leporis	5 01 21·22	+ ·40	+ ·06	·30	− ·01	− ·02	21·35	5 01 25·08	·73	− ·05
E	β Orionis.	09 52·19	+ ·31	+ ·09	− ·28	+ ·01	− ·02	52·86	09 56·64	·78	·10
	Bellatrix	19 55·74	+ ·25	+ ·12	+ ·28	+ ·03	− ·02	56·40	20 00·12	72	− ·04
	B.A.C.1740.....	27 28·44	+ ·53	− ·02	+ ·41	+ ·04	− ·02	29·38	27 32·90	·52	+ ·16
	κ Orionis.	43 09·07	+ ·30	+ ·08	− ·28	+ ·07	− ·02	09·78	43 13·42	·64	+ ·04
	α Orionis.	49 55·24	+ ·25	+ ·12	+ ·28	+ ·09	− ·02	55·96	49 59·67	·71	− ·03

$a = -^{s}\cdot 147 \qquad c = +^{s}\cdot 280$

Chronometer correction at $5^h\ 06^m = +3^s\cdot 684 \pm {}^s\cdot 034$

TRANSIT OBSERVATIONS.

Station: WELLINGTON. Date, December 17th, 1903. Observer: THOS. KING.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = + ·04	s.		h. m. s.	s.	s.
E	ξ^1 Ceti	2 07 51·17	+ ·19	+ ·31	+ ·26	− ·03	− ·02	51·88	2 07 55·41	+3·53	+ ·03
	ϕ Eridani	13 00·97	− ·47	− ·12	+ ·41	− ·03	− ·02	01·68	13 05·33	·65	− ·09
	ξ^2 Ceti..........	22 59·94	+ ·19	+ ·31	+ ·26	− ·02	− ·02	60·66	23 04·06	·40	+ ·16
	ν Ceti..........	30 46·69	+ ·20	+ ·29	+ ·25	− ·01	− ·02	47·40	30 50·95	·55	+ ·01
	γ^2 Ceti...... ..	38 16·07	+ ·21	+ ·28	+ ·25	− ·01	− ·02	16·78	38 20·39	·61	− ·05
W	σ Arietis.......	46 08·57	+ ·25	+ ·34	− ·26	·00	− ·02	08·88	46 12·47	·59	− ·03
	μ Horologii ...	3 01 18·57	+ ·85	− ·26	− ·51	+ ·01	− ·03	18·63	3 01 22·15	·52	+ ·04
	τ^1 Arietis......	15 38·30	+ ·21	+ ·38	− ·27	− ·02	− ·02	38·62	15 42·18	·56	·00
	o Tauri........	19 35·99	+ ·29	+ ·31	− ·26	− ·02	− ·02	36·33	19 39·82	·49	+ ·07
	ΙΙ Tauri........	34 59·49	+ ·22	+ ·40	− ·28	+ ·03	·02	59·84	35 03·51	·67	− ·11

$a = -^s{\cdot}399 \qquad c = +^s{\cdot}254$

Chronometer correction at $2^h\ 51^m = +3^s{\cdot}559 \pm {}^s{\cdot}027$

Station: WELLINGTON. Date, December 18th, 1903. Observer: THOS. KING.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R.A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = + ·04	s.		h. m. s.	s.	s.
E	ξ^1 Ceti..........	2 07 50·27	+ ·21	+ ·32	+ ·24	− ·02	− ·02	51·60	2 07 55·41	+4·41	+ ·07
	ϕ Eridani.......	13 00·03	+ ·51	− ·13	− ·39	− ·02	− ·02	00·76	13 05·31	·55	− ·07
	ξ^2 Ceti..........	22 58·89	+ ·21	+ ·32	+ ·24	− ·01	− ·02	59·63	23 04·06	·43	+ ·05
	δ Ceti..........	34 29·32	+ ·24	+ ·28	+ ·24	− ·01	− ·02	30·05	34 34·50	·45	+ ·03
	γ^2 Ceti..........	38 15·14	+ ·23	+ ·29	+ ·24	·00	− ·02	15·88	38 20·39	·51	− ·03
W	γ Arietis	46 07·73	+ ·21	+ ·36	− ·25	·00	− ·02	08·03	46 12·47	·44	+ ·04
	ϵ Arietis........	53 39·64	+ ·18	+ ·39	− ·26	+ ·01	− ·02	39·94	53 44·39	·45	+ ·03
	μ Horologii.....	3 01 17·79	+ ·69	− ·27	− ·48	+ ·01	− ·03	17·71	3 01 22·13	·42	+ ·06
	τ^1 Arietis.......	15 37·40	+ ·17	+ ·40	− ·26	+ ·02	− ·02	37·71	15 42·18	·47	+ ·01
	o Tauri...	19 34·81	+ ·23	+ ·32	− ·24	+ ·03	− ·02	35·13	19 39·82	·69	− ·21

$a = -^s{\cdot}420 \qquad c = -^s{\cdot}239$

Chronometer correction at $2^h\ 43^m = +4^s{\cdot}479 \pm {}^s{\cdot}029$

W	α Reticuli......	4 13 08·89	+ ·76	− ·21	− ·73	− ·03	− ·03	08·65	4 13 13·29	+4·64	+ ·05
	ϵ Tauri..	22 57·33	+ ·20	+ ·25	− ·36	− ·02	− ·02	57·38	23 01·93	·55	+ ·14
	α Tauri	30 21·16	+ ·21	+ ·23	− ·35	− ·02	− ·02	21·21	30 25·99	·78	− ·09
	τ Tauri	36 25·56	+ ·18	+ ·26	− ·36	− ·01	− ·02	25·61	36 30·33	·72	− ·03
	μ Eridani	40 38·47	+ ·29	+ ·16	− ·34	− ·01	− ·02	38·55	40 43·32	·77	− ·08
E	ι Aurigæ.......	50 40·66	+ ·09	+ ·31	+ ·40	·00	− ·02	41·44	50 46·04	·60	+ ·09
	ϵ Leporis.... ..	5 01 19·67	+ ·30	+ ·10	+ ·36	+ ·01	− ·02	20·42	5 01 25·12	·70	− ·01
	β Orionis	09 51·20	+ ·25	+ ·15	+ ·34	+ ·01	− ·02	51·93	09 56·70	·77	− ·08
	β Bellatrix......	19 54·80	+ ·20	+ ·20	+ ·34	+ ·02	− ·02	55·54	20 00·18	·64	+ ·05
	β Doradûs......	32 44·56	+ ·59	− ·21	+ ·73	+ ·03	− ·03	45·67	32 50·36	·69	·00

$a = -^s{\cdot}268 \qquad c = +^s{\cdot}336$

Chronometer correction at $4^h\ 53^m = +4^s{\cdot}687 \pm {}^s{\cdot}023$

PERSONAL EQUATION.

TRANSIT OBSERVATIONS.

Station: WELLINGTON. Date, January 10th, 1904. Observer: Thos. King.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R.A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·012	s.		h. m. s.	s.	s.
E	o^1 Eridani	4 06 29·16	− ·07	+ ·38	+ ·17	+ ·01	− ·02	29·63	4 07 11·76	+42·13	+ ·01
	ε Tauri	22 18·96	− ·05	+ ·61	+ ·18	+ ·01	− 02	19·69	23 01·92	42·23	− ·09
	α Doradûs	31 15·00	− ·15	− ·28	+ ·30	+ ·01	− ·03	14·85	31 56·83	41·98	+ ·16
	π^1 Orionis.......	43 56·04	− ·06	+ ·50	+ ·17	+ ·01	− ·02	56·64	44 38·95	42·31	− ·17
W	κ Orionis.......	5 42 31·39	− ·02	+ ·35	− ·17	·00	·02	31·53	5 43 13·60	42·07	+ ·07
	1 Geminorum ..	57 36·16	− ·01	+ ·65	− ·19	− ·01	·02	36·58	58 18·65	42·07	+ ·07
	α Argûs........	6 21 09·83	− ·03	− ·22	− ·28	− ·01	− ·03	09·26	6 21 51 57	42·31	− ·17
	γ Geminorum. .	31 29·16	− ·01	+ ·59	− ·18	− ·01	− ·02	29·53	32 11·52	41·99	+ ·15

$a = -{}^s{\cdot}665 \qquad c = +{}^s{\cdot}173$

Chronometer correction at $5^h\ 18^m = +42^s{\cdot}135 \pm {}^s{\cdot}050$

PERSONAL EQUATION.

TRANSIT OBSERVATIONS.

Station: WELLINGTON. Date, January 11th, 1904. Observer: THOS KING.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s r = − ·024	s.		h. m. s.	s.	s.
E	ε Geminorum...	6 37 20·13	+ ·02	+ ·83	+ ·14	+ ·02	− ·02	21·12	6 38 03·20	+42·08	− ·14
	ε Canis Majoris.	54 10·46	+ ·08	+ ·20	+ ·14	+ ·01	− ·02	10·87	54 52·89	42·02	− ·08
	δ Geminorum...	7 13 42·19	+ ·05	+ ·80	+ ·13	+ ·01	− ·02	43·16	7 14 24·99	41·83	+ ·11
	Q Carinæ........	32 37·73	+ ·11	− ·25	+ ·20	·00	− ·03	37·76	33 19·64	41·88	+ ·06
W	ζ Argûs..	59 32·86	+ ·20	+ ·02	− ·16	− ·01	− ·02	32·89	8 00 14·68	41·79	+ ·15
	ε Argûs	8 19 54·36	+ ·29	− ·49	− ·24	− ·02	− ·03	53·87	20 35·89	42·02	− ·08

$a = -{}^s{\cdot}817 \qquad c = +{}^s{\cdot}122$

Chronometer correction at $7^h\ 28^m = +41^s{\cdot}935 \pm {}^s{\cdot}044$

PERSONAL EQUATION.

TRANSIT OBSERVATIONS.

Station: WELLINGTON. Date, January 10th, 1904. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
			s.	s.	s.	s. r = −·012	s.		h. m. s.	s.	s.
E	η Tauri	3 41 05·34	−·04	+·68	+·23	+·01	−·02	06·20	3 41 47·80	+41·60	−·01
	γ¹ Eridani .. .	52 51·95	−·08	+·32	+·22	+·01	−·02	52·40	53 33·95	·55	+·04
	ω¹ Tauri	4 02 53·18	−·05	+·63	+·23	+·01	−·02	53·98	4 03 35·55	·57	+·02
	α Reticuli.......	12 31·44	−·18	−·55	+·46	+·01	−·03	31·15	13 12·73	·58	+·01
	τ Tauri.........	35 47·83	−·04	+·67	+·23	·00	−·02	48·67	36 30·33	·66	−·07
W	ε Leporis	5 00 43·65	−·06	+·25	−·23	·00	−·02	43·59	5 01 25·11	·52	+·07
	γ Orionis........	19 18·63	−·04	+·38	−·22	·00	−·02	18·73	20 00·27	·54	+·05
	β Doradûs	32 09·65	−·12	−·54	−·46	−·01	−·03	08·49	32 50·12	·63	−·04
	α Orionis..	49 18·02	−·04	+·52	−·22	−·01	−·02	18·25	49 59·91	·66	−·07
	η Geminorum ..	6 08 24·61	−·03	+·67	−·23	−·01	−·02	24·99	6 09 06·55	·56	+·03

$a = -^{s}{\cdot}689 \qquad c = +^{s}{\cdot}213$

Chronometer correction at $4^h\ 54^m = +41^s{\cdot}586 \pm {}^{s}{\cdot}014$

PERSONAL EQUATION.

TRANSIT OBSERVATIONS.

Station: WELLINGTON. Date, January 11th, 1904. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = −·012	s.		h. m. s.	s.	s.
E	γ Geminorum...	6 31 29·21	+·03	+·66	+·10	+·01	−·02	29·99	6 32 11·52	+41·53	−·01
	α Pictoris......	46 34·34	+·10	−·56	+·20	·00	−·03	34·05	47 15·57	·52	·00
	δ Canis Majoris.	7 03 49·06	+·05	+·22	+·10	·00	−·02	49·41	7 04 30·96	·55	−·03
	β Canis Minoris.	21 16·04	+·03	+·58	+·09	·00	−·02	16·72	21 58·21	·49	+·03
W	ξ Argûs	44 35·25	+·22	+·24	−·10	·00	−·02	35·59	45 17·11	·52	·00
	γ Argûs	8 05 55·34	+·31	−·11	−·14	−·01	−·02	55·37	8 06 36·89	·52	00

$a = -^{s}{\cdot}754 \qquad c = -^{s}{\cdot}093$

Chronometer correction at $7^h\ 15^m = +41^s{\cdot}521 \pm {}^{s}{\cdot}008$

Hence the weighted mean, King anticipates Klotz $^{s}{\cdot}257 \pm {}^{s}{\cdot}045$

PERSONAL EQUATION.

TRANSIT OBSERVATIONS.

Station : OTTAWA. Date, June 22nd, 1904. Observer : F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·14	s.		h. m. s.	m. s.	s.
E	201............	15 15 24·42	− ·06	+ ·03	− ·55	+ ·07	− ·02	23·89	15 11 39·88	−3 44·01	+ ·02
	203............	24 40·21	− ·05	− ·18	−1·50	+ ·06	− ·05	38·49	20 54·52	43·97	− ·02
	205............	27 38·81	− ·01	+ ·04	− ·53	+ ·04	− ·02	38·33	23 54·26	44·07	+ ·08
	206............	31 15·42	+ ·01	+ ·01	− ·61	+ ·03	− ·02	14·84	27 30·80	44·04	+ ·05
	593............	33 56·21	+ ·01	+ ·11	− ·47	+ ·03	− ·02	55·87	30 11·87	44·00	+ ·01
	212............	43 18·88	+ ·04	+ ·08	− ·46	·00	− ·01	18·53	39 34·62	43·91	− ·08
W	217............	51 12·67	− ·07	+ ·38	+2·23	− ·01	− ·07	15·13	47 31·16	43·97	− ·02
	221............	16 09 30·30	+ ·04	·00	+ ·65	− ·06	− ·02	30·91	16 05 46·90	44·01	+ ·02
	222............	13 05·02	+ ·02	− ·11	+ ·46	− ·07	− ·01	05·31	09 21·35	43·96	− ·03
	223............	17 00·56	+ ·03	− ·11	+ ·46	− ·07	− ·01	00·86	13 16·98	43·88	·11
	225............	21 27·09	+ ·05	− ·07	+ ·49	− ·08	− ·02	27·46	17 43·39	44·07	+ ·08
	473............	24 45·19	+ ·05	− ·08	+ ·47	− ·09	− ·02	45·52	21 01·47	44·05	+ ·06

$a_1 = +{}^{s}\cdot121$ $a_2 = -{}^{s}\cdot146$ $c = {}^{s}\cdot460$

Chronometer correction at $15^h\ 45^m = -3^m\ 43^s\cdot993 \pm {}^{s}\cdot014$

W	229............	16 31 55·52	+ ·15	− ·02	+1·07	+ ·07	− ·04	56·75	16 28 12·76	−3 43·99	− ·10
	230............	34 46·33	+ ·08	·00	+ ·52	+ ·06	− ·02	46·97	31 02 78	44·19	+ ·10
	231............	41 25·98	+ ·07	·00	+ ·45	+ ·04	− ·02	26·52	37 42·44	44·08	− ·01
	232............	43 22·17	+ ·08	·00	+ ·50	+ ·04	− ·02	22·77	39 38·59	44·18	+ ·09
	478............	51 28·60	+ ·05	+ ·01	+ ·40	+ ·02	− ·02	29·06	47 45·00	44·06	− ·03
	233............	56 53·44	+ ·05	+ ·01	+ ·39	+ ·01	− ·01	53·89	53 09·87	44·02	− ·07
E	234............	17 00 23·71	+ ·15	·00	− ·45	·00	− ·02	23·39	56 39·36	44·03	− ·06
	598............	08 39·67	+ ·07	+ ·01	− ·40	− ·02	− ·02	39·31	17 04 55·12	44·19	+ ·10
	236............	12 18·13	+ ·31	− ·01	− ·94	− ·03	− ·04	17·42	08 33·37	44·05	·04
	238............	14 52·23	+ ·14	·00	− ·42	− ·03	− ·02	51·90	11 07·73	44·17	+ ·08
	241............	34 15·59	+ ·12	+ ·01	− ·39	− ·08	− ·02	15·23	30 31·18	44·05	− ·04

$a = +{}^{s}\cdot015$ $c = -{}^{s}\cdot384$

Chronometer correction at $17^h\ 00^m = -3^m\ 44^s\cdot095 \pm {}^{s}\cdot016$

PERSONAL EQUATION.

TRANSIT OBSERVATIONS.

Station : OTTAWA. Date, June 22nd, 1904. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·14	s.		h. m. s.	m. s.	s.
E	201	15 15 23·01	·00	+ ·16	+ ·42	− ·07	− ·02	23·64	15 11 39·88	−3 43·76	− ·09
	203	24 38·22	+ ·08	−1·01	+1·15	+ ·06	− ·05	38·45	20 54·52	·93	+ ·08
	205	27 37·37	+ ·04	+ ·22	+ ·40	+ ·04	− ·02	38·05	23 54·26	·79	− ·06
	206	31 13·94	+ ·05	+ ·07	+ ·47	+ ·03	− ·02	14·54	27 30·80	·74	− ·11
	593	33 54·74	+ ·03	+ ·61	+ ·36	+ ·03	− ·02	55·75	30 11·87	·88	+ ·03
	212	43 17·73	+ ·04	+ ·43	+ ·36	·00	− ·01	18·55	39 34·62	·93	+ ·08
W	217	51 19·60	− ·99	−1·79	−1·71	− ·01	− ·07	15·03	47 31·16	·87	− ·02
	221	16 09 31·58	− ·35	+ ·01	− ·50	− ·06	− ·02	30·66	16 05 46·90	·76	− ·09
	222	13 05·37	− ·16	+ ·51	− ·35	− ·07	− ·01	05·29	09 21·35	·94	+ ·09
	223	17 00·95	− ·16	+ ·53	− ·35	− ·07	− ·01	00·89	13 16·98	·91	+ ·06
	225	21 27·68	− ·23	+ ·32	− ·37	− ·08	− ·02	27·30	17 43·39	·91	+ ·06
	473	24 45·63	− ·21	+ ·36	− ·36	− ·09	− ·02	45·31	20 01·47	·84	− ·01

$a = +^{s}\cdot685$ $c = +^{s}\cdot352$

Chronometer correction at $15^{h}\ 45^{m} = -3^{m}\ 43^{s}\cdot855 \pm ^{s}\cdot016$

W	229	16 31 59·09	− ·53	− ·67	− ·99	+ ·07	− ·04	56·93	16 28 12·76	−3 44·17	+ ·14
	230	34 47·44	− ·32	+ ·04	·48	+ ·06	− ·02	46·72	31 02·78	43·94	− ·09
	231	41 26·80	− ·27	+ ·17	− ·41	+ ·04	− ·02	26·31	37 42·44	43·87	− ·16
	232	43 23·23	− ·30	− ·08	− ·46	+ ·04	− ·02	22·57	39 38·59	43·98	− ·05
	478	51 29·28	·21	+ ·32	− ·37	+ ·02	·00	29·04	47 45·00	44·04	+ ·01
	233	56 54·12	− ·19	+ ·36	− ·36	+ ·01	− ·01	53·93	53 09·87	44·06	+ ·03
E	234	17 00 22·72	+ ·08	+ ·18	+ ·41	·00	− ·02	23·37	56 39·36	44·01	− ·02
	598	08 38·33	+ ·04	+ ·55	+ ·37	− ·02	− ·02	39·25	17 04 55·12	44·13	+ ·10
	236	12 16·95	+ ·16	− ·52	+ ·87	− ·03	− ·04	17·39	08 33·37	44·02	− ·01
	238	14 51·07	+ ·07	+ ·24	+ ·39	− ·03	− ·02	51·72	11 07·73	43·99	− ·04
	241	34 14·58	+ ·06	+ ·34	+ ·36	− ·08	− ·02	15·24	30 31·18	44·06	+ ·03
	600	35 51·41	+ ·04	+ ·55	+ ·37	− ·08	− ·02	52·27	32 08·19	44·08	+ ·05

$a = -^{s}\cdot607$ $c = +^{s}\cdot354$

Chronometer correction at $17^{h}00^{m} = -3^{m}\ 44^{s}\cdot033 \pm ^{s}\cdot017$

PERSONAL EQUATION.

TRANSIT OBSERVATIONS.

Station : OTTAWA. Date, June 23rd, 1904. Observer: F. W. O. WERRY.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	r.
		h. m. s.	s.	s.	s.	s. r = − ·14	s.		h. m. s.	m. s.	s.
E	182..........	13 53 55·41	06	+ ·10	− ·10	+ ·07	− ·02	55·40	13 50 08·45	−3 46·95	− ·03
	183..........	14 00 34·36	− ·06	+ ·15	− ·09	+ ·06	·01	34·41	56 47·49	46·92	·06
	184..........	05 35·98	·09	− ·17	·21	+ ·04	·04	35·51	14 01 48·40	47·11	− ·13
	458..........	09 49·88	− ·03	+ ·08	·10	+ ·04	02	49·85	06 02·91	46·94	·04
	185..........	11 35·40	·02	+ ·19	− ·09	+ ·03	·02	35·49	07 48·52	46·97	·01
	186..........	14 47·63	·03	+ ·17	− ·09	+ ·02	− ·01	47·69	11 00·80	46·89	− ·09
	188..........	16 32·66	− ·01	− ·01	·13	+ ·02	·02	32 51	12 45·53	46·98	·00
W	191..........	27 04·14	·02	+ ·16	·09	·00	01	04 40	23 17·40	47·00	·02
	192..........	31 30·19	·02	+ ·07	·10	− ·02	·02	30·34	27 43·27	47·07	·09
	194..........	40 01·55	·03	·11	·09	− ·03	·02	01·73	36 14·78	46·95	− ·03
	196..........	41 48·98	·02	+ 17	·09	− ·04	·01	49·21	38 02 18	47·03	− 05
	197..........	45 12·65	+ ·02	+ ·15	·09	− ·05	− ·02	12 84	41 25·77	47 07	·09
	198..........	54 47·21	·10	− ·41	·34	− ·07	06	47 11	51 00.20	46·91	− ·07

$a = {}^{s}\cdot 223$ $c = {}^{s}\cdot 09$

Chronometer correction at $14^{h}\ 25^{m} = -3^{m}\ 46^{s}\cdot 983 \pm {}^{s}\cdot 014$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	r.
W	465..........	15 04 08·92	·06	01	10	·07	− ·02	09·12	15 00 21·83	−3 47·29	+ ·08
	201..........	15 26·91	+ ·08	·01	+ ·11	− ·04	− ·02	27·11	11 39·87	·24	+ ·03
	203..........	24 41·10	+ 22	+ ·05	+ 30	·02	− ·05	41·64	20 54 47	·17	− ·04
	205..........	27 41·31	+ ·08	01	+ ·11	+ ·02	− ·02	41·49	23 54·25	·24	+ 03
	206..........	31 17·88	+ ·12	·00	+ ·11	+ ·01	− ·02	18·10	27 30·80	·30	+ ·09
E	212..........	43 21·80	+ 11	02	·09	·01	− ·01	21·78	39 34·61	·17	·04
	213..........	45 34·84	+ ·13	·01	·10	− ·03	− ·02	34·81	41 47·60	·21	·00
	215..........	48 14·47	+ 13	− ·01	·10	− ·03	− ·02	14·44	44 27·29	·15	06
	217..........	51 18·23	+ ·57	+ ·08	− ·45	− ·04	− ·07	18·32	47 31·10	·22	+ ·01
	221..........	16 09 34·10	+ ·21	·00	·13	− ·08	− ·02	34·08	16 05 46·89	·19	02
	222..........	13 08·58	+ ·10	02	·09	08	− ·01	08·48	09 21·34	14	− ·07

$a = -{}^{s}\cdot 030$ $c = -{}^{s}\cdot 093$

Chronometer correction at $15^{h}\ 30^{m} = -3^{m}\ 47^{s}\cdot 210 \pm {}^{s}\cdot 012$

PERSONAL EQUATION.

TRANSIT OBSERVATIONS.

Station : OTTAWA. Date, June 23rd, 1904. Observer : OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·14	s.		h. m. s.	m. s.	s.
E	183	14 00 33·77	+ ·04	+ ·52	+ ·03	+ ·06	− ·01	34·41	13 56 47·49	−3 46·92	+ ·05
	184	05 35·71	+ ·11	− ·59	+ ·07	+ ·04	− ·04	35·30	14 01 48·40	·90	− ·03
	458	09 49·35	+ ·06	+ ·29	+ ·03	+ ·01	− ·02	49·75	06 02·91	·84	03
	185	11 34·71	+ ·03	+ ·63	+ ·03	+ ·03	02	35·41	07 48 52	·89	− ·02
	186	14 47·07	+ ·04	+ ·59	+ ·03	+ 02	− ·01	47·74	11 00·80	·94	− ·07
	188	16 32·21	+ ·10	·02	+ 04	+ 02	− ·02	32 33	12 45·53	·80	·07
W	191	27 03·85	− ·12	+ ·55	·03	·00	− ·01	04.21	23 17·40	·84	− 03
	192	31 30·20	− ·22	+ ·23	·03	01	− ·02	30·15	27 43·27	·88	+ ·01
	194	40 01·39	− ·16	+ ·38	− ·03	·03	− ·02	01·53	36 14 78	·75	− ·12
	196	41 48·72	− ·11	+ ·59	03	·04	− ·01	49·12	38 02 18	·94	+ ·07
	197	45 12·38	− ·13	+ ·51	− ·03	·05	− ·02	12·66	41 25·77	·89	+ ·02
	198	54 49·27	− ·57	1·37	·11	·07	− ·06	47·09	51 00·20	·89	+ ·02

$a = -^{s}·755 \qquad c = -^{s}·027$

Chronometer correction at $14^{h}\ 25^{m} = -3^{m}\ 46^{s}·872 \pm {}^{s}·013$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	199	15 02 08·65	− ·23	+ ·09	+ ·02	+ ·07	− ·02	08·58	14 58 21·56	−3 47·02	− ·05
	465	04 08·70	− ·18	+ ·29	+ ·02	+ 07	− ·02	08·88	15 00 21·83	·05	− ·02
	201	15 26 88	− ·20	+ ·20	+ ·02	+ ·04	− ·02	26·92	11 39·87	·05	·02
	203	24 43·30	·51	−1·23	+ ·05	+ ·02	− ·05	41·58	20 54·47	·11	+ ·04
	205	27 41 20	− ·19	+ ·27	+ ·02	+ ·02	− ·02	41·30	23 54·25	05	− ·02
	206	31 17·98	− .23	+ ·08	+ ·02	+ ·01	− ·02	17·84	27 30 80	·04	·03
E	212	43 21 14	+ ·11	+ ·52	− ·02	·01	− ·01	21·73	39 34 61	·12	+ ·05
	213	45 34·20	+ ·12	·42	− ·02	− 03	− 02	34·67	41 47·60	.07	·00
	215	48 13·87	+ ·13	+ ·40	− ·02	·03	− ·02	14 33	44 27·29	·04	− ·03
	217	51 19·96	+ ·55	−2·18	− ·08	− ·04	− ·07	18·14	47 31·10	·04	− ·03
	222	16 13 07·91	+ 09	+ ·62	− 02	− ·08	− ·01	08·51	16 09 21·34	·17	+ 10

$a = +^{s}·834 \qquad c = -^{s}·016$

Chronometer correction at $15^{h}\ 30^{m} = -3^{m}\ 47^{s}·073 \pm {}^{s}·010$

PERSONAL EQUATION.

TRANSIT OBSERVATIONS.

Station : OTTAWA. Date, June 24th, 1904. Observer : F. W. O. WERRY

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	r
		h. m. s.	s.	s.	s.	s. r = − ·14	s.		h. m. s.	m. s.	s.
E.	182..	13 53 58·65	− ·08	+ ·07	− ·09	+ ·07	− ·02	58·60	13 50 08·44	-3 50·16	− ·10
	183............	14 00 37·69	− ·05	+ ·10	− ·09	+ ·06	− ·01	37·70	56 47·48	·22	− ·04
	184..	05 39 18	− ·12	·11	·21	+ ·05	− ·04	38·75	14 01 48·36	·39	+ ·13
	458.............	09 53·22	− ·02	+ ·06	·10	+ ·04	− ·02	53·18	06 02·90	·28	+ ·02
	185.....	11 38 66	− ·02	+ 12	− ·09	+ ·03	− ·02	38·68	07 48 51	·17	− ·09
	186.......... .	14 51·00	− ·01	+ 11	·09	+ ·02	− ·01	51·02	11 00·80	·22	− ·04
W	192..	31 33·55	− ·08	+ ·04	+ ·10	− 01	·02	33·58	27 43·26	·32	+ ·06
	194.............	40 04·91	− ·06	+ ·07	+ ·09	·03	− ·02	04·96	36 14·78	·18	− ·08
	196............	41 52·38	− ·03	+ 11	+ ·09	− ·04	− ·01	52·50	38 02·17	·33	+ ·07
	197.............	45 15 97	− ·03	+ ·10	+ ·09	·05	− ·02	16·06	41 25·76	·30	+ ·04
	590..	49 26 65	− ·02	+ ·13	+ ·09	·06	− ·02	26·77	45 36·38	·39	+ ·13
	198..	54 50·50	− 09	·27	+ ·34	·07	·06	50·35	51 00·14	·21	− ·05

$a = -{}^{s}\cdot146$ $c = {}^{s}\ 088$

Chronometer correction at $14^{h}\ 25^{m} = -3^{m}\ 50^{s}\cdot266 \pm {}^{s}\cdot016$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	r
W	465.............	15 04 12·25	− ·02	+ ·06	+ ·11	+ ·09	− ·02	12·47	15 00 21·82	-3 50·65	+ ·06
	201.............	15 30·25	·01	+ ·04	+ ·10	+ ·07	− ·02	30·43	11 39 86	·57	− ·02
	467.......... ..	17 24·26	·00	·18	+ ·23	+ ·06	− ·04	24·33	13 33·81	·52	− ·07
	202........... ..	24 44·19	·00	+ ·03	+ ·11	+ ·04	− ·02	44·35	20 53·73	·62	+ ·03
	205.....	27 44·58	·00	+ ·06	+ ·10	+ ·04	− ·02	44·76	23 54 24.	·52	− ·07
	206....	31 21·36	·00	+ ·02	+ 11	+ 03	− ·02	21·50	27 30·79	·71	+ 12
E	212..	43 25·15	+ ·07	− ·12	− ·09	·00	− ·01	25·24	39 34·61	·63	+ ·04
	213..	45 38·15	+ ·08	− ·09	− ·09	·00	− ·02	38·21	41 47·60	·61	+ ·02
	215.............	48 17·85	+ ·08	− ·09	·09	·01	− ·02	17·90	44 27·28	·62	+ ·03
	217.......	51 22·22	+ ·37	·48	− ·42	·02	− ·07	21 60	47 31·03	·57	− ·02
	597.............	16 35 45·46	+ ·06	+ ·15	− ·09	− ·12	− ·02	45·44	16 31 54·98	·46	− ·13
	232.............	43 29·27	+ ·15	+ ·03	·11	·14	− ·02	29·18	39 38·58	·60	+ 01

$a = +{}^{s}\cdot184$ $c = -{}^{s}\cdot087$

Chronometer correction at $15^{h}\ 40^{m} = -3^{m}\ 50^{s}\cdot589 \pm {}^{s}\cdot015$

PERSONAL EQUATION.

TRANSIT OBSERVATIONS.

Station : OTTAWA. Date, June 24th, 1904. Observer: OTTO KLOTZ.

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
		h. m. s.	s.	s.	s.	s. r = − ·14	s.		h. m. s.	m. s.	s.
E	182	13 53 58·05	+·16	+·39	·06	·07	−·02	58·59	13 50 08·44	−3 50·15	−·05
	183	14 09 37·02	·13	+·57	·06	+·06	−·01	37·71	56 47·48	·23	+·02
	184	05 38·91	44	−·65	13	+·05	−·04	38·58	14 01 48 36	·22	+·01
	458	09 52·58	·22	+·32	·06	+·04	−·02	53·08	06 02 90	·18	−·03
	185	11 37·99	·12	+·69	06	+·03	−·02	38·75	07 48 51	·24	+·03
	186	14 50·28	14	+·65	06	+·02	−·01	51·02	11 00·80	22	+·01
W	192	31 33·29	·16	+·25	+·07	·01	−·02	33·42	27 43 26	16	05
	194	40 04·59	13	+·42	+·06	03	02	04·89	36 14 78	·11	−·10
	196	41 51·87	09	+·65	+·06	04	−·01	52·44	38 02·17	·27	+·06
	197	45 15·55	11	+·57	+·06	·05	−·02	16·00	41 25·76	·24	+·03
	198	54 52·26	47	−1·51	+·21	·07	−·06	50·36	51 00 14	22	01
	199	15 02 11·92	·19	+·09	+·07	·08	−·02	11·79	58 21 55	·24	+·03

a = −·831 c = −·657

Chronometer correction at $14^h\ 25^m = -3^m\ 50^s\cdot206 \pm {}^s\cdot011$

Clamp.	Star.	Transit over mean of threads.	Level and inequality of pivots.	Azimuth.	Collimation.	Rate.	Aberration.	Seconds of corr. transit.	R. A.	Chronometer correction.	v.
W	465	15 04 11·94	·10	+·30	+·03	+·09	−·02	12·24	15 00 21 82	−3 50·42	·00
	201	15 30·12	·11	+·21	+·04	+·07	−·02	30 31	11 39 86	·45	+·03
	467	17 25·28	·24	−·86	·08	+·06	−·04	24·28	13 33 81	47	+·05
	202	24 44·02	12	·15	·04	+·04	−·02	44 11	20 53 73	·38	−·04
	205	27 44·40	·11	+·27	+·03	+·04	−·02	44·61	23 54·24	·37	−·05
	206	31 21·19	·13	·09	·04	+·03	−·02	21·20	27 30·79	41	−·01
E	212	43 24·42	·18	·54	03	00	−·01	25·10	39 34·61	·49	−·07
	213	45 37·46	+·21	·44	03	·00	−·02	38·06	41 47·60	·46	+·04
	215	48 17.20	+·21	·41	·03	−·01	−·02	17·76	44 27·28	·48	+·06
	217	51 23.00	·93	−2·25	·15	−·02	−·07	21·44	47 31 03	·41	−·01
	597	16 35 44·70	+·13	·72	·03	−·12	−·02	45 38	16 31 54·98	·40	−·02
	232	43 28·68	+·29	·12	04	−·14	−·02	28·89	39 38·58	·31	−·11

a = +·858 c = ·030

Chronometer correction at $15^h\ 40^m = -3^m\ 50^s\cdot426 \pm {}^s\cdot012$

PERSONAL EQUATION.

KLOTZ—WERRY.

Date.	Clock Correction.						K – W
	Klotz.			Werry.			
1904.	m.	s.	s.	m.	s.	s.	s.
June 22	– 3	43·855	±·016	– 3	43·993	±·014	+·138
" 22		44·033	±·017		44·095	±·016	+·062
" 23		46·872	±·013		46·983	±·014	+·111
" 23		47·073	±·010		47·210	±·012	+·137
" 24		50·206	±·011		50·266	±·016	+·060
" 24		50·426	±·012		50·589	±·015	+·163

	s.	s.
Weighted mean	+·116	±·011
Klotz transit west of Werry's	+·008	
Klotz anticipates Werry	·124	±·011

DIFFERENCE OF LONGITUDE.

From the preceding observations and their clock corrections combined with the times of exchange, we obtain the following differences of longitude between the successive stations, and subsequent final values.

The Canadian longitude values are based on the longitude of

Montreal. . . . . $4^{h.}$ $54^{m.}$ $18{\cdot}634^{sec.} \pm {\cdot}049^{sec.}$

Ottawa was connected in 1896 with Montreal, the observers, Dr. King and Prof. McLeod, exchanging stations and the value obtained

Ottawa. . . . . $5^{h.}$ $02^{m.}$ $50{\cdot}022^{sec.} \pm {\cdot}049^{sec.}$

In 1900 Vancouver was connected by a direct circuit of 3,000 miles with Ottawa. The observers, Dr. King and Dr. Klotz, exchanging stations also.

Vancouver. . . . . $8^{h.}$ $12^{m.}$ $28{\cdot}368^{sec.} \pm {\cdot}050^{sec.}$

This last value is the initial one for the Transpacific longitudes

DIFFERENCE OF LONGITUDE.

VANCOUVER—FANNING.

Date.	Direction.	Sidereal Time. Bamfield.	Sidereal Time. Vancouver.	Difference.	Relative rate per hour.	Transmission time.	Chronometer Correction. Vancouver.	Chronometer Correction. Fanning.	Difference from Bamfield Chronometer.
1903.		h. m.	h. m.	h. m. s.	s.	s.	s.	m. s.	h. m. s.
April 15	B. to V	12 13·98	12 11·80	-0 02 10·585					
	V. to B	12 15·59	12 13·41	10·672		·039			
	Mean	12 14·79	12 12·61	0 02 10·629					
	B. to V	12 48·70	12 46·50	0 02 10·771					
	V. to B	12 49·90	12 47·70	10·891		·056			
	Mean	12 49·30	12 47·10	0 02 10·831					
	General Mean	12 32·05	12 29·85	0 02 10·730	·351				
	*	12 28·55		0 02 10·710			-47·253		-0 02 57·963
		Bamfield.	Fanning.						
	B. to F	12 27·40	9 58·10	2 29 19·073					
	F. to B.	12 29·70	10 00·40	19·771	·410	·341			
	Mean	12 28·55	9 59·25	2 29 19·422				+1 15·780	+2 28 03·642

h. m. s.
Difference of longitude, Vancouver-Fanning .... +2 25 05·679

* Note.—As explained in the text, Bamfield was simply used as an exchange station and no observations were made there. The exchange Bamfield-Vancouver was over a land line, while Bamfield-Fanning was over the cable. The difference of the two exchanges Bamfield-Vancouver, made before and after the Fanning exchange, was reduced to the mean time of exchange with Fanning by applying the rates of the Bamfield and Vancouver chronometers, the latter was known from the observations, while the former was obtained from the differential rate, shown by the two exchanges, and the Vancouver rate.

Date.	Direction.	Sidereal Time. Bamfield.	Sidereal Time. Vancouver.	Difference.	Relative rate per hour.	Transmission time.	Chronometer Correction. Vancouver.	Chronometer Correction. Fanning.	Difference from Bamfield Chronometer.
1903.		h. m.	h. m.	h. m. s.	s.	s.	s.	s.	h. m. s.
April 16	B. to V	12 12·78	12 10·46	0 02 19·029					
	V. to B	12 14·50	12 12·30	19·132		·047			
	Mean	12 13·64	12 11·38	0 02 19·081					
	B. to V	12 50·50	12 48·20	0 02 19·211					
	V. to B	12 51·94	12 49·62	19·310		·046			
	Mean	12 51·22	12 48·91	0 02 19·261					
	General Mean	12 32·43	12 30·15	0 02 19·171	·286				
		12 42·33		0 02 19·218			-45·624		-0 03 04·842
		Bamfield.	Fanning.						
	B. to F	12 41·25	10 11·70	2 29 29·688					
	F. to B	12 43·40	10 13·90	30·372	·419	·335			
	Mean	12 42·33	10 12·80	2 29 30·030				+1 19·622	+2 28 10·408

h. m. s.
Difference of longitude, Vancouver-Fanning .... +2 25 05·566

Date.	Direction.	Sidereal Time. Bamfield.	Sidereal Time. Vancouver.	Difference.	Relative rate per hour.	Transmission time.	Chronometer Correction. Vancouver.	Chronometer Correction. Fanning.	Difference from Bamfield Chronometer.
1903.		h. m.	h. m.	h. m. s.	s.	s.	s.	m. s.	h. m. s.
April 18	B. to V	12 13·95	12 11·40	0 02 33·577					
	V. to B	12 15 60	12 13·05	33·677	....	·047			
	Mean	12 14·78	12 12·23	0 02 33·627					
	B. to V	12 45 85	12 43·30	0 02 33·709					
	V. to B	12 47·11	12 44·55	33·801	...	·039			
	Mean	12 46·48	12 43·93	0 02 33·755					
	General Mean	12 30·63	12 28·08	0 02 33·691	·241				
		12 36·55	....	0 02 33 714	....	....	43·349	......	−0 03 17·063
		Bamfield.	Fanning.						
	B. to F	12 35·50	10 04·80	2 30 48·373					
	F. to B	12 37·60	10 06·80	49·046	·434	·329			
	Mean	12 36·55	10 05·80	2 30 48·710	... ...	....	....	+2 26·102	+2 28 22·608

	h. m. s.
Difference of longitude, Vancouver–Fanning	+2 25 05·545

Date.	Direction.	Sidereal Time. Bamfield.	Sidereal Time. Vancouver.	Difference.	Relative rate per hour.	Transmission time.	Chronometer Correction. Vancouver.	Chronometer Correction. Fanning.	Difference from Bamfield Chronometer.
1903.		h. m.	h. m.	h. m. s.	s.	s.	s.	s.	h. m. s.
April 23	B. to V	12 28·90	12 25·70	0 03 11·912					
	V. to B'	12 30·30	12 27 10	12·027	...	·054			
	Mean	12 29·60	12 26·40	0 03 11·970					
	B. to V	12 50·30	12 47 10	0 03 12·025					
	V. to B	12 51·80	12 48·60	12·127	......	·048			
	Mean	12 51·05	12 47·85	0 03 12·076					
	General Mean	12 40·33	12 37·13	0 03 12·023	·297				
		12 40·35	....	0 03 12·023	.. ..	...	·34·541	....	−0 03 46·564
		Bamfield.	Fanning.						
	B. to F	12 39·40	10 09·80	2 29 37·974					
	F. to B	12 41·30	10 11 70	38·682	·386	·348			
	Mean	12 40·35	10 10·75	2 29 38·328	....	......	....	+46·272	+2 28 52·05

	h. m. s.
Difference of longitude, Vancouver–Fanning	+2 25 05·492

Date.	Direction.	Sidereal Time. Bamfield.	Sidereal Time. Vancouver.	Difference.	Relative rate per hour.	Transmission time.	Chronometer Correction. Vancouver.	Chronometer Correction. Fanning.	Difference from Bamfield Chronometer.
1903.		h. m.	h. m.	h. m. s.	s.	s.	s.	s.	h. m. s.
April 26	B. to V	13 05·97	13 02·42	0 03 33·040					
	V. to B	13 07·30	03·74	33·137	......	·045			
	Mean	13 06·64	13 03·08	0 03 33·089					
	B. to V	13 29·50	13 25·94	0 03 33·157					
	V. to B	13 30·90	27·34	33·228	....	·032			
	Mean	13 30·20	13 26·64	0 03 33·193					
	General Mean	13 18·42	13 14·86	0 03 33·141	265				
		13 19·00	....	0 03 33·143	.....	.. .	−29·390	....	−0 04 02·533
		Bamfield.	Fanning.						
	B. to F	13 18·00	10 47·90	2 30 06·793					
	F. to B....... .	13 20·00	10 49·90	07·519	331	·357			
	Mean	13 19·00	10 48·90	2 30 07·156	. .	....	....	+59·140	+2 29 08·016

h. m. s.

Difference of longitude, Vancouver–Fanning...... .. .. 2 25 05·483

VANCOUVER–FANNING.

1903.		h. m. s.	s.
April 15..	Difference of longitude	2 25 05·679±	·019
" 16..	"	5·566±	·016
" 18..	"	5·545±	·025
" 23..	"	5·492±	·010
" 26..	"	5·483±	·015
	Weighted Mean	2 25 05·530±	·021
	Personal Equation	− ·124	
	Difference of Longitude	2 25 05·406±	·021
	Vancouver	8 12 28·368±	·050
	Longitude of Fanning	10 37 33·774±	·054

FANNING—SUVA.

Date.	Direction.	Sidereal Time. Fanning.	Sidereal Time. Suva.	Difference.	Relative rate per interval.	Transmission time.	Chronometer Correction. Fanning	Chronometer Correction. Suva.	Difference of Longitude.
1903.		h. m.	h. m.	h. m. s.	s.	s.	s.	m. s	h. m. s.
June 2, 3	F. to S......	15 43·5	14 18·0	1 25 29·641					
	S. to F......	15 45·9	14 20·4	30·196	+·007	·281			
	Mean.....	15 44·7	14 19·2	1 25 29·919	...	.....	14·333	-3 28·085	1 28 43·671
" 3, 4	F. to S......	15 49·9	14 24·5	1 25 24·605					
	S. to F......	15 51·8	14 26·4	25·134	+·008	·269			
	Mean.....	15 50·85	14 25·45	1 25 24·870	...	....	−12·328	3 31·132	43·674
" 8, 9	F. to S.. ...	15 56·6	14 31·6	1 25 02·034					
	S. to F...	15 58·7	14 33·7	02·585	+·008	·280			
	Mean. ...	15 57·65	14 32·65	1 25 02·310	.....	.....	3·691	3 45·124	43·743
" 9, 10	F. to S. ..	15 36·4	14 11·4	1 24 58·577					
	S. to F....	15 38·2	14 13·2	59·157	+·006	·293			
	Mean.....	15 37·3	14 12·3	1 24 58·867	...	......	2·541	−3 47·425	43·751
" 10, 11	F. to S.....	16 05·5	14 40·6	1 24 54·401					
	S. to F.....	16 07·5	14 42·6	54·962	+·007	·284			
	Mean.....	16 06·5	14 41·6	1 24 54·682	......	......	− 0·926	3 49·954	43·710
" 15, 16	F. to S....	16 46·1	15 21·5	1 24 34·187					
	S. to F....	16 48·6	15 24·0	34·766	+·004	·291			
	Mean......	16 47·35	15 22·75	1 24 34·477	......	.....	+ 6·716	-4 02·519	43·712
" 21, 22	F. to S.. ..	16 47·1	15 22·9	1 24 12·284					
	S. to F. ...	16 48·9	15 24·7	12·812	+·004	·266			
	Mean.....	16 48·0	15 23·8	1 24 12·548	.....	.....	+14·836	-4 16·375	43·759
" 23, 24	F. to S....	16 59·9	15 35·8	1 24 04·826					
	S. to F. ...	17 01·7	15 37·6	05·400	+·006	·290			
	Mean....	17 00·8	15 36·7	1 24 05·113	......	......	+17·842	−4 20·767	43·722

Fanning—Suva.

		h. m. s. s.
1903,		
June 2, 3..	Difference of longitude	1 28 43·671± ·016
" 3, 4..	"	43·674± ·013
" 8, 9..	"	43·743± ·019
" 9, 10..	"	43·751± ·017
" 10, 11..	"	43·710± ·014
" 15, 16..	"	43·712± ·016
" 21, 22..	"	43·759± ·017
" 23, 24..	"	43·722± ·021
	Weighted mean........................	1 28 43·713± ·008
	Personal equation........................	+ ·124
	Difference of longitude........................	1 28 43·837± ·008
	Fanning........................	10 37 33·774± ·054
	Longitude of Suva........................	12 06 17·611± ·055
	or east........................	11 53 42·389± ·055

SUVA—NORFOLK.

Date.	Direction.	Sidereal Time. Suva.	Sidereal Time. Norfolk.	Difference.	Relative rate.	Transmission time.	Chronometer Correction. Suva.	Chronometer Correction. Norfolk.	Difference of Longitude.
1903.		h. m.	h. m.	h. m. s.	s.	s.	s.	m. s.	m. s.
Aug. 14	N. to S.....	19 15·7	18 34·2	0 41 28·261					
	S. to N.. ..	19 17·5	18 36·0	27·994	+·006	·137			
	Mean. ..	19 16·6	18 35·1	41 28·128	......	.....	−26·307	− 59·614	42 01·435
" 17	N. to S.....	19 09·0	18 27·8	41 09·356					
	S. to N....	19 11·0	18 29·9	9·060	+·003	·149			
	Mean.....	19 10·0	18 28·85	41 09·208	.....	.. .	−31·304	−1 23·475	01·379
" 19	N. to S.....	19 14·8	18 33·9	40 56·028					
	S. to N..	19 17·4	18 36·5	55·767	+·011	·136			
	Mean.....	19 16·1	18 35·2	40 55·898	. ...	......	−34·307	−1 39·750	01·341
" 22	N. to S	19 38·7	18 58·1	40 38·245					
	S. to N. ..	19 40·7	19 00·1	37·978	+·006	·137			
	Mean.....	19 39·7	18 59·1	40 38·112	.....	.....	−38·877	−2 02·145	01·380
" 23	N. to S. .	20 03·8	19 23·3	40 32·221					
	S. to N. ...	20 05·7	19 25·2	31·951	+·008	·139			
	Mean....	20 04·75	19 24·25	40 32·086	......	.....	−40·377	−2 09·653	01·362
" 27	N. to S.....	20 14·5	19 34·4	40 03·871					
	S. to N.....	20 16·5	19 36·4	03·581	+·009	·149			
	Mean....	20 15·5	19 35·4	40 03.726	. ...	.....	−42·931	−2 40·528	01·323

Suva Norfolk.

1903.		h. m. s. s.
Aug. 14..	Difference of longitude	0 42 01·435 ± ·017
" 17..	"	01·379 ± ·018
" 19..	"	01·341 ± ·019
" 22..	"	01·380 ± ·014
" 23..	"	01·362 ± ·024
" 27..	"	01·323 ± ·013
	Weighted mean	0 42 01·367 ± ·011
	Personal equation	− ·124
	Difference of longitude	0 42 01·243 ± ·011
	Suva	11 53 42·389 ± ·055
	Longitude of Norfolk	11 11 41·146 ± ·055

NORFOLK—SOUTHPORT.

Date.	Direction.	Sidereal Time. Norfolk.	Sidereal Time. Southport	Difference.	Relative rate.	Transmission time.	Chronometer Correction. Norfolk.	Chronometer Correction. Southport	Difference of Longitude.
1903.		h. m.	h. m.	h. m. s.	s.	s.	m. s.	m. s.	m. s.
Oct. 1	N. to S	23 21·4	22 23·3	0 58 05·322					
	S. to N ...	23 23·8	22 25·7	05·506	+ ·010	·097			
	Mean ...	23 22·6	22 24·5	58 05·414	....	....	– 27·353	– 23·174	58 01·235
" 3	N. to S	22 54·9	21 57·0	57 55·332					
	S. to N	22 56·5	21 58·6	55·524	+ ·003	·098			
	Mean	22 55·7	21 57·8	57 55·428	.....	.....	– 42·317	– 48·083	01·194
" 11	N. to S	23 20·0	22 22·4	57 38·363					
	S. to N	23 21·6	22 23·95	38·567	+ ·006	·105			
	Mean	23 20·8	22 23·18	57 38·465	....	....	–1 54·659	–2 17·430	01·236
" 12	N. to S	23 26·7	22 29·2	57 33·158					
	S. to N	23 28·12	22 30·56	33·362	+ ·003	·104			
	Mean	23 27·41	22 29·88	57 33·260	....	......	–2 01·112	–2 29·084	01·232
" 16	N. to S	23 34 5	22 37·3	57 13·983					
	S. to N	23 35·9	22 38·7	14·165	+ ·006	·094			
	Mean	23 35·2	22 38·0	57 14·074	......	...	–2 27·886	–3 15 089	01·277

Norfolk-Southport.

1903.			h. m. s.	s.
Oct.	1..	Difference of longitude	0 58 01·235±	·018
"	3.	"	·194±	·019
"	11 .	"	·236±	·013
"	12..	"	·232±	·014
	16 .	"	·277±	·013
		Weighted Mean	0 58 01 240±	·008
		Personal Equation	+ ·124	
		Difference of Longitude........	0 58 01·364±	·008
		Norfolk	11 11 41·146±	·056
		Longitude of Southport	10 13 39·782±	·056

SOUTHPORT—SYDNEY.

Date.	Direction.	Sidereal Time. South-port.	Sidereal Time. Sydney.	Difference.	Relative rate.	Transmission time.	Chronometer Correction. South-port.	Chronometer Correction. Sydney.	Personal Equation. K-R	Personal Equation. K-L	Difference of Longitude.
1903.		h. m.	h. m.	h. m. s.	s.	s.	m. s.		s.	s.	m. s.
Sept. 29	Sy. to S..	22 49·4	22 40·6	0 08 50·208	– ·041	·142		Sydney Observatory applied its clock correction to time of exchange, and is included in column 'Difference'.			
	S. to Sy..	22 44·0	22 35·2	49·883							
	Mean..	22 46·7	22 37·9	8 50·046	......	......	0·485		...	– ·018	8 50·513
Oct. 2	Sy. to S..	22 40·2	22 30·8	9 25·887	– ·050	·137					
	S. to Sy..	22 35·6	22 26·2	25·563							
	Mean..	22 37·9	22 28·5	9 25·725	.	...	35·181		+ ·067	...	50·611
" 3	Sy. to S..	22 52·42	22 42·76	9 39·158	– ·042	·146					
	S. to Sy..	22 47·85	22 38·20	38·824							
	Mean..	22 50·14	22 40·48	9 38·991	...	..	– 48·506		+ ·067	....	50·552
" 6	Sy. to S..	23 11·11	23 00·95	10 11·567	– ·061	·126					
	S. to Sy..	23 03·00	22 52·80	11·254							
	Mean.	23 07·06	22 56·87	10 11·410	.	.	1 20·948		....	– ·018	50·444
" 7	Sy. to S..	23 11·0	23 00·64	10 22·141	·041	·145					
	S. to Sy..	23 05·6	22 55·24	21·811							
	Mean..	23 08·3	22 57·94	10 21·976	......	.	–1 31·543		+ ·067	......	50·500
" 8	Sy. to S..	23 22·15	23 11·60	10 33·821	– ·048	·141					
	S. to Sy..	23 16·88	23 06·32	33·492							
	Mean.	23 19·52	23 08·96	10 33·657	....	......	–1 43·281		+ ·067	.....	50·443

SOUTHPORT-SYDNEY.

1903.		h. m. s.	s.
Sept. 29..	Difference of longitude	0 08 50·513	± ·029
Oct. 2..	"	·611	± ·024
" 3..	"	·552	± ·015
" 6..	"	·444	± ·016
" 7..	"	·500	± ·013
" 8..	"	·443	± ·013
	Weighted Mean	0 08 50·495	± ·016
	Southport	10 13 39·782	± ·056
	Longitude of Sydney	10 04 49·287	± ·058

SOUTHPORT—BRISBANE.

Date.	Direction.	Sidereal Time. South-port.	Sidereal Time. Brisbane.	Difference.	Relative rate.	Transmission time.	Chronometer Correction. South-port.	Chronometer Correction. Brisbane.	Difference of Longitude.
1903.		h. m.	h. m.	h. m. s.	s.	s.	m. s.	s.	m. s.
Sept. 29	S. to B	21 57·63	21 55·33	0 02 18·607					
	B. to S	22 02·10	21 59·80	18·609	− ·031	neg.			
	Mean	21 59·87	21 57·57	2 18·608	....	......	+ ·805	+45·726	1 33·688
Oct. 2	S. to B ..	22 07·60	22 04·66	2 55·699					
	B. to S	22 09·30	22 06·40	55·715	·017	·000			
	Mean	22 08·45	22 05·53	2 55·707 ...		.....	− 34·882	+47·207	33·6
" 3	S. to B	22 08·30	22 05·15	3 09·733					
	B. to S .. .	22 10·33	22 07·15	9·763	− ·016	·007			
	Mean	22 09·32	22 06·15	3 09·748 ..	.	.. .	− 48·176	+47·963	33·609
" 6	S. to B	22 20·40	22 16·70	3 44·796					
	B. to S	22 25·78	22 22·03	44·829	− ·035	·000			
	Mean	22 23·09	22 19·37	3 44·813	.	...	−1 20·656	+50·637	33·520
" 7	S. to B	22 33·86	22 29·92	3 56·396					
	B. to S	22 36·60	22 32·70	56·431	− ·019	·008			
	Mean	22 35·23	22 31·31	3 56·414		.... .	−1 31·328	+51·504	33·582

Southport–Brisbane.

1903.		h. m. s.	s.
September 29..	Difference of longitude	0 01 33·688	± ·018
October 2..	"	·618	± ·015
" 3..	"	·609	± ·013
" 6..	"	·520	± ·011
" 7..	"	·582	± ·013
	Weighted Mean	0 01 33·585	± ·018
	Personal Equation..............................	+ ·153	± ·044
	Difference of Longitude..............................	0 01 33·738	± ·047
	Southport	10 13 39·782	± ·056
	Longitude of Brisbane..............................	10 12 06·044	± ·073

NORFOLK—DOUBTLESS BAY.

Date.	Direction.	Sidereal Time.		Difference.	Relative rate.	Transmission time.	Chronometer Correction.		Difference of Longitude.
		Doubtless Bay.	Norfolk.				Doubtless Bay.	Norfolk.	
1903.		h. m.	h. m.	h. m. s.	s.	s.	m. s.	m. s.	m. s.
Dec. 5	N. to D.B. .	2 23·7	2 01·5	0 22 14·386					
	D.B. to N	2 25·4	2 03·2	14·255	·004	·067			
	Mean	2 24·55	2 02·35	22 14·321	......	...	− 17·342	− 18·073	22 15·052
" 9	N. to D.B .	2 34·9	2 12·3	22 37·132					
	D.B. to N. .	2 36·4	2 13·8	37·027	·005	·055			
	Mean ...	2 35·65	2 13·05	22 37·080		......	−1 06·460	− 44·527	15·147
" 10	N. to D.B.	2 35·1	2 12·4	22 42·160					
	D.B. to N. .	2 36·6	2 13·9	42·101	·004	·032			
	Mean	2 35·85	2 13·15	22 42·131	....	...	−1 18·274	− 51·215	15·072
" 11	N. to D.B. .	2 55·5	2 32·7	22 47·251					
	D.B. to N. .	2 57·1	2 34·3	47·131	·005	·062			
	Mean	2 56·3	2 33·5	22 47·191	...	....	−1 29·662	− 57·545	15·074
" 17	N. to D.B. .	3 15·8	2 52·5	23 18·124					
	D.B. to N. .	3 17·3	2 54·0	18·018	·002	·054			
	Mean	3 16·55	2 53·25	23 18·071	...	....	−2 39·513	−1 36·667	15·225
" 18	N. to D.B.	3 12·4	2 49·0	23 21·872					
	D.B. to N. .	3 13·8	2 50·4	21·738	·003	·068			
	Mean	3 13·1	2 49·7	23 21·805	...	...	−2 50·020	−1 43·443	15·228

NORFOLK–DOUBTLESS BAY.

1903.		h. m. s.	s.
December 5. .	Difference of longitude	0 22 15·052	± ·020
" 9. .	"	·147	± ·020
" 10. .	"	·072	± ·014
" 11. .	"	·074	± ·015
" 17. .	"	·225	± ·020
" 18. .	"	·228	± ·017
	Weighted Mean	0 22 15·124	± ·021
	Personal Equation	− ·124	
	Difference of Longitude	0 22 15·000	± ·021
	Norfolk	11 11 41·146	± ·056
	Longitude of Doubtless Bay	11 33 56·146	± ·060

DOUBTLESS BAY—WELLINGTON.

Date.	Direction.	Sidereal Time. Wellington.	Sidereal Time. Doubtless Bay.	Difference.	Relative rate.	Transmission time.	Chronometer Correction. Wellington.	Chronometer Correction. Doubtless Bay.	Difference of Longitude
1903.		h. m.	h. m.	h. m. s.	s.	s.	s.	m. s.	m. s.
Dec. 6	W. to D.B. .	3 20·67	3 15·96	0 04 42·655	·347	·019			
	D.B. to W. .	2 44·47	2 39·74	43·039					
	Mean	3 02·57	2 57·85	4 42·847	. . .	. . . .	5·189	31·573	5 09·231
" 7	W. to D.B. .	3 27·24	3 22·77	4 28·059	·096	·018			
	D.B. to W. .	3 16·17	3 11·70	28·191					
	Mean	3 21·70	3 17·23	4 28·125	. .	. . .	3·180	44·255	09·200
" 11	W. to D.B. .	3 31·66	3 28·02	3 38·167	·076	·026			
	D.B. to W. .	3 23·39	3 19·76	38·296					
	Mean.	3 27·53	3 23·89	3 38·232	.	. . .	+1·119	−1 29·874	09·225
" 12	W. to D.B. .	3 41·72	3 38·32	3 24·142					
	D.B. to W. .	4 01·58	3 58·18	24·018	+·171	·024			
	Mean.	3 51·65	3 48·25	3 24·080	. .	. . . .	+3·530	−1 41·546	09·156
" 17	W. to D.B. .	4 05·70	4 03·27	2 25·720	+·144	·041			
	D.B. to W. .	4 26·16	4 23·73	25·659					
	Mean.	4 15·93	4 13·50	2 25·690	. . . .	. . . . . .	+3·702	−2 39·818	09·210
" 18	W. to D.B. .	3 52·85	3 50·61	2 14·365	·083	−·010			
	D.B. to W. .	3 42·20	3 39·95	14·428					
	Mean	3 47·53	3 45·28	2 14·397	. . . . .	. . . . .	+4·582	−2 50·220	09·199

DOUBTLESS BAY WELLINGTON.

		h. m. s.	s.
Dec. 6. .	Difference of longitude	0 05 09·231 ±	·027
" 7. .	"	·200 ±	·018
" 11. .	"	·225 ±	·032
" 12. .	"	·156 ±	·021
" 17 .	"	·210 ±	·032
" 18. .	"	·199 ±	·020
	Weighted mean.	0 05 09·198 ±	·007
	Personal equation.	− ·257 ±	·045
	Difference of longitude	0 05 08·941 ±	·045
	Doubtless Bay	11 53 56·146 ±	·060
	Wellington	11 39 05·087 ±	·075

CLOSING ERRORS.

Fanning.—Reducing the longitude given on Admiralty Chart 2971, for 'Observation Spot' at English Harbour, by scaling to that of the observatory we obtain for the latter:—

	159°	23′	27″
The Canadian value is..	159°	23′	26″·61

that is, the values are practically identical, which speaks volumes for the accuracy of the hydrographic survey, which is principally dependent upon the transport of chronometers for the determination of longitude.

Captain Fanning writes, p. 225, in the work cited, 'These islands are situate in latitude 3° 51′ 30″ north, longitude 159° 12′ 30″ west.' The description is rather vague, but the position in longitude by a trading vessel, as Fanning's was, is pretty good for the year 1798.

Suva.—On Admiralty Chart 1660 of Suva Harbour, the longitude of 'Observation Spot,' south end of Walou bridge, is given as 178° 26′ 00″ E.; the observatory at the Cable station is 14″·21 west thereof, so that the longitude of the latter, based on the former becomes:—

	178°	25′	45″·79 E.
The Canadian value is	178°	25′	35″·84
Difference. ..			9″·95 = ·663$^{sec.}$ or 960 feet = 320 yards.

It may be interesting here to quote a paragraph of the opening address by the late Rear-Admiral, Sir W. J. L. Wharton, president of Section E., Geography, at the British Association meeting in South Africa last August. After speaking of the great merit of the sextant and chronometer for the determination of longitude at sea, he says: 'To give an idea of the comparative accuracy of the chronometer (transport of) method, I may mention that in taking at hazard eleven places distributed all over the world at great distances from England, the longitudes of which have been recently determined by means of the electric telegraph and elaborate series of observations, I find that the average difference between the chronometer and the telegraphic positions is 700 yards.'—So that the accordance at Suva is quite satisfactory.

Norfolk.—On Admiralty Chart 1110, 'Norfolk and Philip Islands' the longitude of 'Observation Spot' at the foot of Boat Harbour, Sydney Bay, is given as 167° 58′ 06″. Reducing this to the position, by scaling from the chart, of the observatory at the Cable station, Anson Bay, at the northwestern part of the island we obtain for the longitude of the observatory:—

	167°	55′	47″
The Canadian value is..	167°	55′	17″·19
Difference..			29″·81 = 1·99$^{sec.}$

This is undoubtedly a large difference. The Admiralty determination is an old one, having been made by Captain Denham, R.N., in 1855, and measured through Lord Howe island from Garden island, Sydney, the latter being then not well determined.

Southport.—Southport, Queensland, is undoubtedly of the three Australian longitudes obtained by the Canadian connection, the best determined. In the first place the other two Australian stations—Sydney and Brisbane—are dependent upon it, and hence must necessarily have less weight, being an additional link in the chain; in the next place the personal equation is more thoroughly and satisfactorily eliminated for Southport than for the other two stations. As already stated the number of stations across the Pacific is an odd number—five—and as the observers occupied alternate stations from Vancouver to Southport, the personal equation even as an unknown quantity, which it is not, disappears in the value for Southport. And furthermore, the longitude work up to Southport (and Doubtless Bay also) was homogeneous in every respect, the instruments, apparatus, methods of the two observers were identical, so that the value for Southport deserves *a priori* a high degree of confidence.

There is however, no value for Southport, based by triangulation on the Brisbane longitude, available for comparison with the Canadian value. A comparison with Australian values we obtain, however, at Sydney and at Brisbane.

Sydney.—We have for Sydney, six independent determinations for difference of longitude with Southport, together with observations for personal equation between the observers, Mr. Lenehan and Mr. Raymond at Sydney, and Dr. Klotz at Southport.

In the following table is given the comparison between the longitude of Sydney as brought from Madras and Singapore and that *via* Canada and the British Pacific Cable.

In the reduction (1885) of the Australian longitudes, the longitude of Madras was accepted as:—

$5^{h.}\ 20^{m.}\ 59^{s}\cdot 42$,*

and the derived value of Sydney was:—

$10^{h.}\ 04^{m.}\ 49^{s}\cdot 54$.

In making the comparison, the best and most recent available data are utilized for the longitude of Madras. The values for the various links or arcs between Madras and Sydney have not been re-determined since 1882-84, so that they will be adopted now as then.

For arriving at the longitude of Madras, we have the following data:—

Arc.	Difference of Longitude.			Probable Error.	Authority.
	h.	m.	s.	s.	
Greenwich—Potsdam	0	52	16·051	±·0030	Professor Albrecht.[1]
Potsdam—Tehran	2	33	24·228	±·0068	Major Burrard.[2]
Tehran—Bushire	0	02	21·443	±·0083	"
Bushire—Karachi	1	04	44·787	±·0073	"
Karachi—Bombay	0	23	12·196	±·0129	"
Bombay—Bolarum	0	22	48·801	±·0061	"
Bolarum—Madras	0	06	54·615	±·0085	"

Station.	Longitude East.			Probable Error.
	h.	m.	s.	s.
Potsdam	0	52	16·051	±·0030
Tehran	3	25	40·279	±·0074
Bushire	3	23	18·836	±·0111
Karachi	4	28	03·623	±·0133
Bombay	4	51	15·819	±·0185
Bolarum	5	14	04·620	±·0195
Madras	5	20	59·235	±·0213

* Report on the Telegraphic Determination of Australian longitudes, 1886, p. 31.
[1] Bestimmung der Längendifferenz Potsdam-Greenwich, 1903.
[2] Great Trigonometrical Survey of India, Vol. XVII, p. XIV.

Applying now the published values for the arcs between Madras and Sydney, we obtain the following series:—

Arc.	Difference of Longitude.			†Probable Error.	Authority.
	h.	m.	s.	s.	
Madras	5	20	59·235	± ·0213	
Madras—Singapore	1	34	25·58	± ·0270	Davis and Norris (U.S. Navy).*
Singapore—Flagstaff	−0	00	01·50		
Flagstaff—Capt. Darwin's Station	+0	00	01·51		
Capt. Darwin's Station	6	55	24·825	± ·0344	
Darwin's Station—Port Darwin	1	47	57·48	± ·0310	
Port Darwin	8	43	22·305	± ·0463	
Port Darwin—Adelaide	0	30	57·81	± ·0277	
Adelaide	9	14	20·115	± ·0540	
Adelaide—Melbourne	0	25	33·84	± ·0337	
Melbourne	9	39	53·955	± ·0636	
Melbourne—Sydney	0	24	55·40	± ·0614	
Sydney	10	04	49·355	± ·0884	
Canadian value	10	04	49·287	± ·058	
**Difference			·068		
	= 1″.02				
	= 84 feet.				

† The probable errors given for difference of longitude are taken from Appendix, Table I, p. 23 of P. Baracchi's report 'On the most Probable Value and Errors of Australian Longitudes,' 1895.

* Telegraphic Determination of Longitude in the East Indies, China and Japan, 1881–2.

** Since the above result was obtained, Astronomische Nachrichten, No. 3993, has appeared, containing 'Ausgleichung des Zentraleuropäischen Längennetzes' by Professor Th. Albrecht. The adjustment of the net involved 176 differences of longitude between 79 stations. In the final values Potsdam is given as $52^{m}\ 16^{s}{\cdot}062 \pm {}^{s}{\cdot}0135$ for the same meridian as given in the above table as $52^{m}\ 16^{s}{\cdot}051 \pm {}^{s}{\cdot}003$. That is, the adjusted longitude of Potsdam is greater than the direct measure of Prof. Albrecht and Mr. Wanach in 1903 by ${}^{s}{\cdot}011$. If we adopt the adjusted value for Potsdam, the longitude of Madras will be increased by ${}^{s}{\cdot}011$, that is, becomes $5^{h}\ 20^{m}\ 59^{s}{\cdot}246$, and similarly that of Sydney, $10^{h}\ 04^{m}\ 49^{s}{\cdot}366$. Differing from the Canadian value by ${}^{s}{\cdot}079$.

In the above-mentioned Astron. Nach. pp. 153-154, are given the results of the 1902 campaign for the arc Greenwich-Paris. The two Greenwich observers (with exchange of stations for eliminating personal equation) obtained the value of $9^{m}\ 20{\cdot}976^{sec} \pm {\cdot}011^{sec}$ in the spring, and in the autumn $9^{m}\ 20{\cdot}911^{sec} \pm {\cdot}004^{sec}$, giving a difference of ${\cdot}065^{sec}$ between the two independent determinations. Similarly the French observers obtained the values of $9^{m}\ 20{\cdot}932^{sec}$ and $9^{m}\ 21{\cdot}029^{sec}$, showing a difference of ${\cdot}097^{sec}$.

That is, the first girdle of the world closed within 84 feet. Apparently the weakest link in the girdle is the arc, Madras-Singapore, since no observations for personal equation were made at the time by Lieut. Commander C. H. Davis and Lieut. S. A. Norris, the observers respectively at Madras and Singapore.

However in the United States Navy Report quoted, Lieut. Commander F. M. Green says, p. 18, 'By means of the repeated use of the personal equation machine of Professor Eastman, at the Naval Observatory, it was found that the habitual errors of the observers engaged in this measurement had all the same sign; that is, they habitually observed the transit of a star a few hundredths of a second after its occurrence, but their respective differences were so small that it seemed evident that to introduce results so minute as corrections would not increase the trustworthiness of the result.'

This is important testimony and written at the time with reference to the Madras-Singapore arc. If it does not wholly dispose of the differential personal equation involved, it gives assurance of its very small magnitude.

In Mr. Barrachi's report quoted, he is slightly in error when speaking of the above arc; he says: 'Their personal equation was continuously tested by absolute personal equation instruments, each observer being provided with one.'

The difference of longitude Madras-Singapore as determined by Davis and Norris was, after due consideration and discussion, accepted by the Australian astronomers—Ellery, Todd and Russell—for the determination of Australian longitudes.

Brisbane.—The position of the observatory here is given in the Nautical Almanac as $10^{h.}\ 12^{m.}\ 06\cdot40^{sec.}$ The derivation of this value becomes apparent from the following extract from the Annual Report of the Department of Public Lands for the year 1891, Queensland.

Under sub-division 'Trigonometrical Survey' the Surveyor General under date of April 8, 1892, p. 10, says: 'Additional care was bestowed upon the determination of Burketown, as opportunity was taken there, with the kind permission of Mr. Russell, the Government Astronomer of New South Wales, of bringing Sydney Observatory into the telegraphic circuit, and of thus determining, not only the longitude of Burketown, but the difference of longitude between Sydney and Brisbane, both by direct and indirect means. The results so obtained, together with a previous determination made in 1884, and a subsequent one in the present year, have been investigated both by Mr. Russell and ourselves, and are as follows:—

	m.	s.	
1884.	7	16·81	diff. Brisbane-Sydney.
1891.	7	16·87	
1891.	7	16·88	
1892.	7	16·88	

'Considering that different observers and different methods were employed upon these determinations, the resulting mean of $7^{m.}\ 16\cdot86^{sec.}$ must be looked upon as possessing a very high degree of accuracy, and as Brisbane is on the initial meridian from which all our differences of longitude have been reckoned, the result is very gratifying. Assuming the longitude of Sydney Observatory to be $10^{h.}\ 4^{m.}\ 49\cdot54^{sec.}$, and the difference of longitude between Sydney and Brisbane observations to be $7^{m.}\ 16\cdot86^{sec.}$, the resulting longitude of Brisbane Observatory is $10^{h.}\ 12^{m.}\ 6\cdot40^{sec.}$'

Through the longitude determinations of Professor Albrecht and Major Burrard, Madras has suffered a correction of $-\cdot185^{sec.}$, as already shown. Hence the value of Brisbane, dependent upon Madras and Sydney becomes:—

	$10^{h.}$	$12^{m.}$	$06^{s}\cdot215$
The Canadian value is	$10^{h.}$	$12^{m.}$	$06^{s}\cdot044$
Difference.... ..			$^{s}\cdot171 = 2''\cdot565 = 231$ feet.

Taking the Canadian values for Sydney and Brisbane we find the difference of longitude between these two places:—

	$7^{m.}$	$16^{s}\cdot757$
While the Australian value is.	$7^{m.}$	$16^{s}\cdot86$
Difference.		$^{s}\cdot103$

It must be remarked that the above comparison is not quite as satisfactory as desired, on account of the value of the differential personal equation obtained three weeks after the longitude campaign.

Mr. T. D. Fraser laboured considerably under a mental and physical strain, on account of very serious illness in his family during the observations. He obtained little rest during the 24 hours for several weeks, and was conscious when observing that he was not in normal condition. He gave little weight to his observations at Southport, although when computed the probable error of the time determination was satisfactory, $\pm\cdot014^{sec.}$, the same as that for his Brisbane observations.

A chain of triangles extends southward from Brisbane to the vicinity of Southport, some fifty miles, so that it will be easy to effect a geodetic connection between the observation stations at Brisbane and Southport, and free from any uncertainty in the differential personal equation.

Doubtless Bay.—The connection between the observatory at the Cable station and the trigonometrical survey of New Zealand was made by Government Surveyor Vin-

cent J. Blake, under instructions of the Surveyor General. The triangulation was extended from Station 20 on the west side of the mouth of Mangonui river westward about two and a half miles to Station A (the magnetic station), and thence to the near-by observatory.

The geographic position of station 20 was furnished by Mr. J. W. A. Marchant, Surveyor General.

We have then:—

Longitude Station 20.. ..	173°	31′	37″·1
Station 20—Sta. A... ..		− 2′	24″·1
Station A..	173°	29′	13″·0
Sta. A—Observatory.. ..		−	3″·66
Observatory..	173°	29′	09″·34
	= 11h.	33m.	56·623sec.
Canadian value is..	11h.	33m.	56·146sec.
Difference..	=		·477sec. = 7″·15 = 595 feet.

It may be remarked that the position of Station 20 is dependent upon the initial station, Mt. Cook at Wellington, through a chain of triangles about seven hundred miles long. From the roughness of the country it was expedient to carry on a network of triangulation for land survey and settlement purposes, and the refinements of a primary triangulation were not aimed at.

In the closing for Wellington it will be found that the difference is ·038sec. or ″·57, and of the same sign as the above, making thereby the difference between the telegraphic determination Wellington-Doubtless Bay, and the one obtained by triangulation ·439sec., equivalent to 549 feet at the latitude of Doubtless Bay.

What was said with reference to Southport of the relative value of the longitude determination there, is equally applicable to Doubtless Bay, as the latter station occupies the same position in the series of stations with reference to personal equation as does the former.

Wellington.—The derivation of the value for the longitude of the Wellington Observatory has already been shown as:—

11h. 39m. 05·31sec.

This requires the correction of − ·185sec., the same as applied to Sydney for the adopted value of Madras, dependent upon the work of Prof. Albrecht and Major Burrard.

We have then for the value of Wellington via Madras and Sydney:—

	11h.	39m.	05·125sec.
Canadian value is..	11h.	39m.	05·087sec.
Difference..			·038sec. = ″·57

It will be noticed that the difference between the closing at Sydney and at Wellington is ·030sec., the Canadian values being in each case less than the ones via Madras. This quantity, ·030sec., apparently represents the accordance between the direct determination of the Sydney-Wellington arc in 1883 and the indirect one via Southport and Doubtless Bay in 1903.

Although observations were made for personal equation by the two observers, yet the conditions under which they were made were not the most favourable. It was impracticable to mount the portable transit at the Wellington observatory, so that the observations were all made with the Wellington instrument, Mr. T. King observing by 'eye and ear,' as is his custom, and Dr. Klotz recorded, as is his custom, electrically, in this case, however, with a specially made make-circuit key for embossing, by means of

the style, the paper fillet of the Morse register—the chronograph of the Wellington observatory. Retardation and parallax of the two styles of the register—the one for the clock and the other for the transits—were carefully determined and applied.

FINAL LONGITUDE VALUES.

Station.	Longitude.							
	Time.			Probable Error.	Arc.			Probable Error.
	h.	m.	s.	s.	°	′	″	″
Vancouver	8	12	28·368	±·050	123	07	05·520 W	± ·75
Fanning	10	37	33·774	±·054	159	23	26·610 W	± ·81
Suva	11	53	42·389	±·055	178	25	35·835 E	± ·82
Norfolk	11	11	41·146	±·055	167	55	17·190 E	± ·82
Southport	10	13	39·782	±·056	153	24	56·730 E	± ·84
Sydney	10	04	49·287	±·058	151	12	19·305 E	± ·87
Brisbane	10	12	06·044	±·073	153	01	30·660 E	±1·09
Doubtless Bay	11	33	56·146	±·060	173	29	02·190 E	± ·90
Wellington	11	39	05·087	±·075	174	46	16·305 E	±1·12

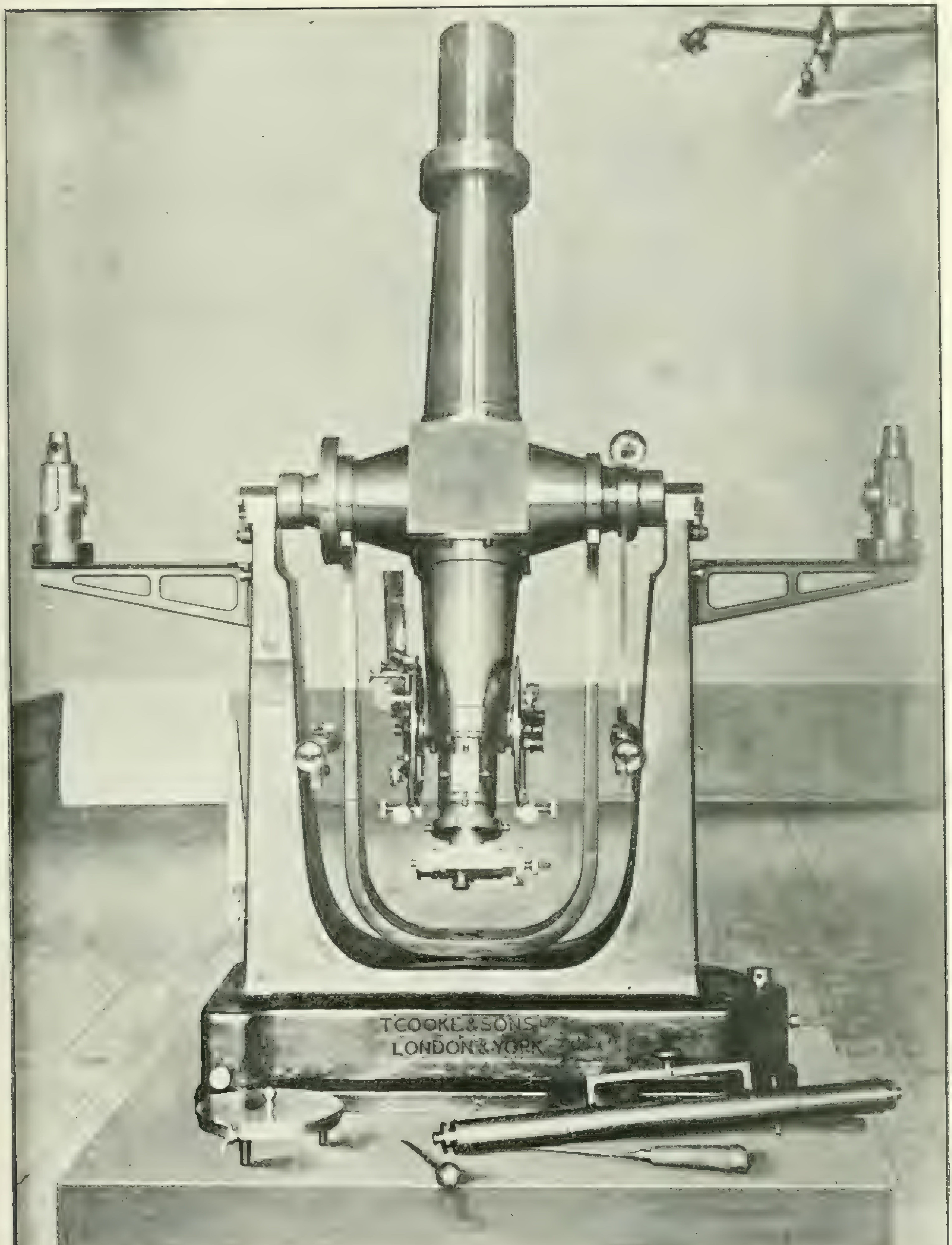


Fig. 1.—Transit.

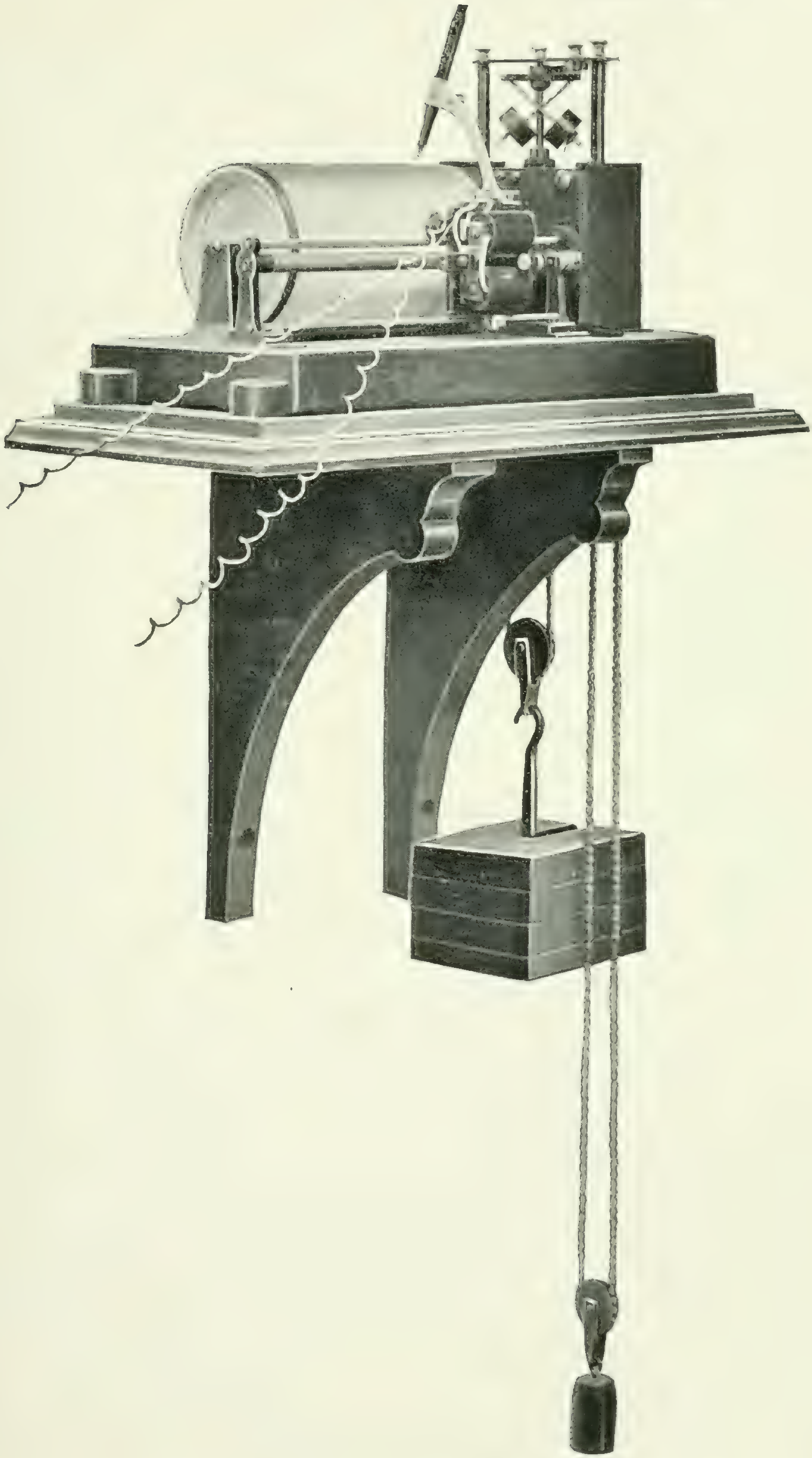


Fig. 2.—Chronograph.

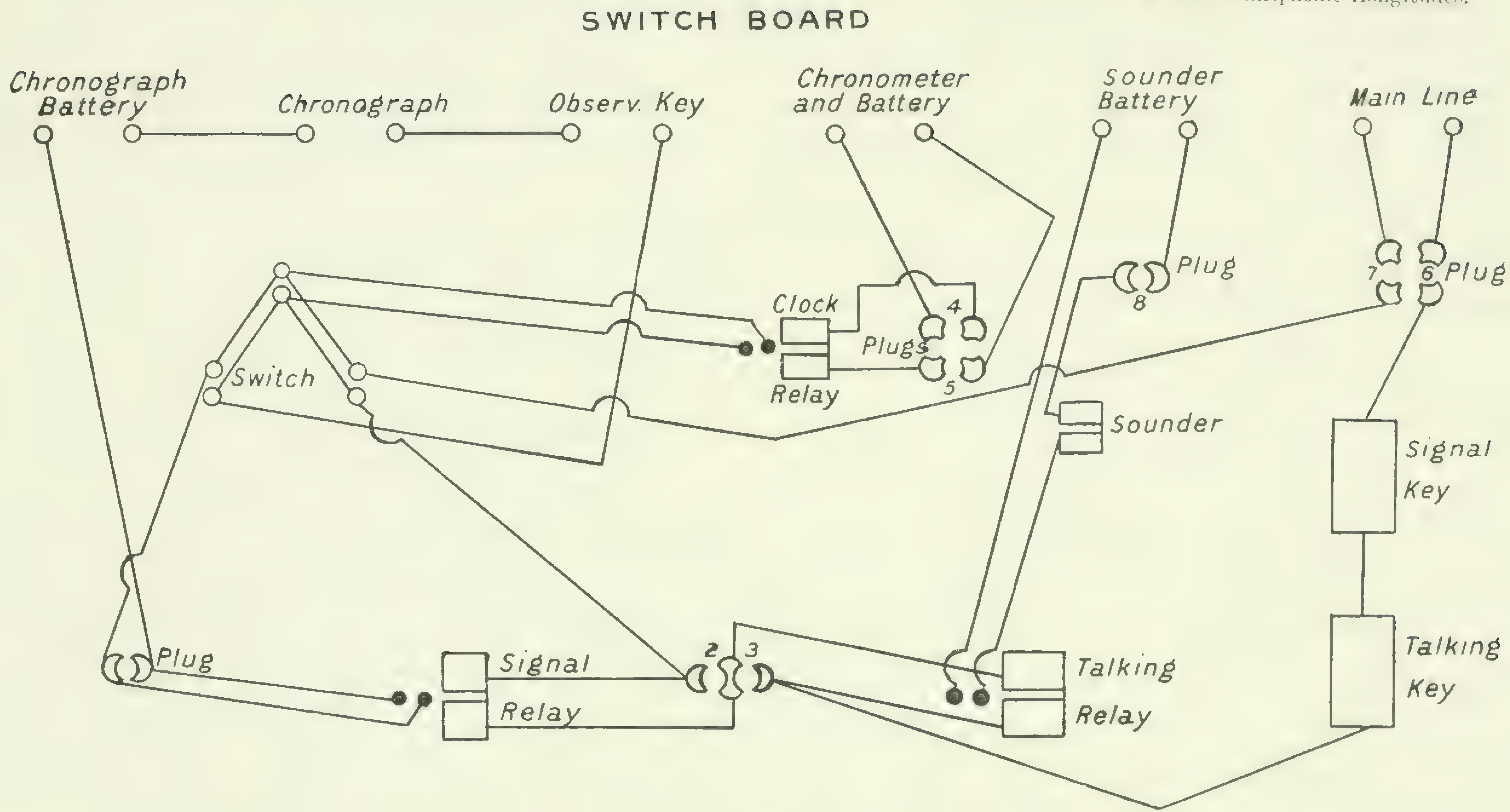

SWITCH BOARD
Chronograph Battery
Chronograph
Observ. Key
Chronometer and Battery
Sounder Battery
Main Line
Clock
Relay
Plugs
4
5
Plug
8
7
6
Plug
Switch
Sounder
Signal Key
Talking Key
Plug
Signal
Relay
2
3
Talking
Relay

Fig. 3.

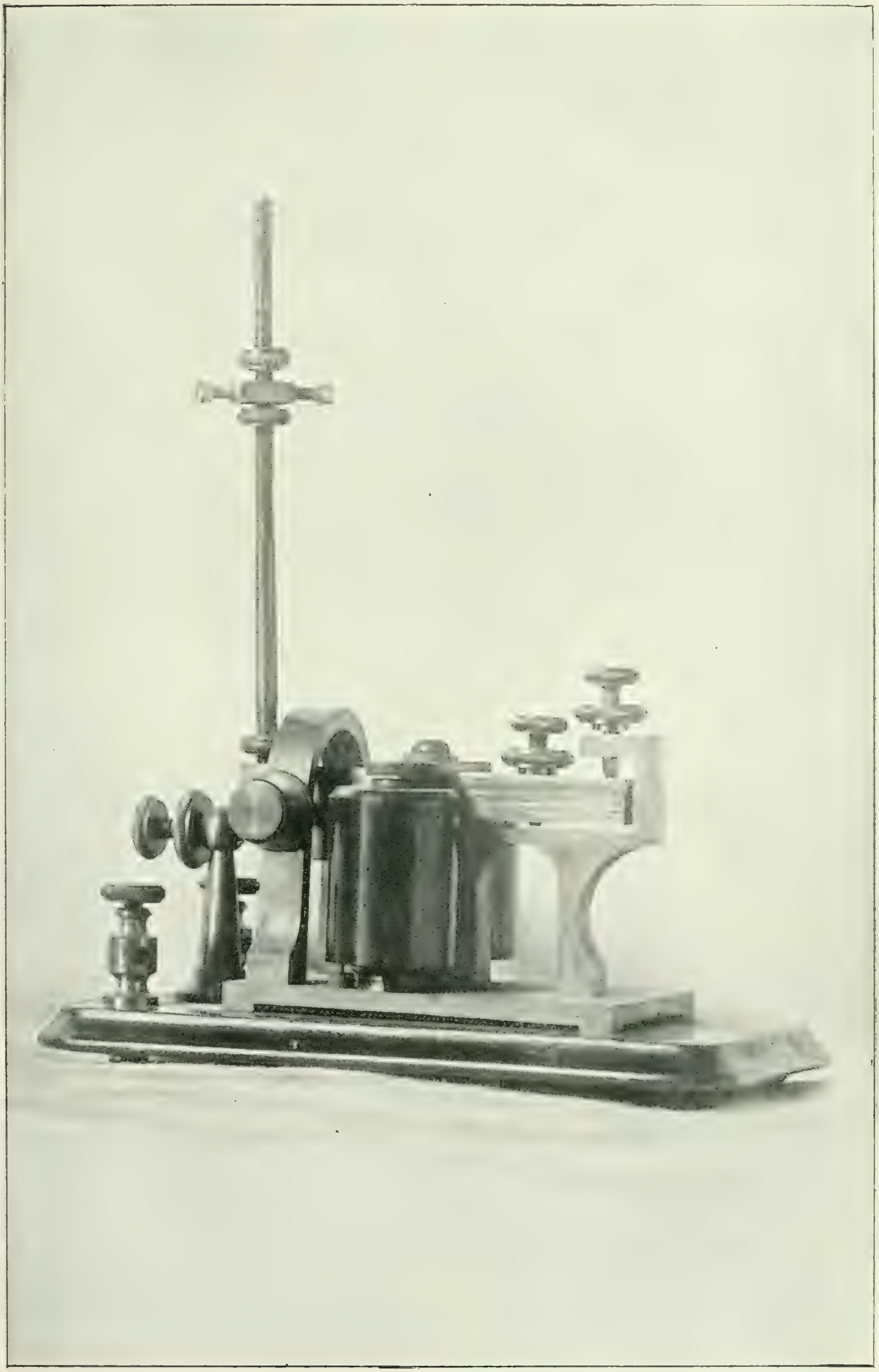


Fig. 4.—Sounder for Clock Cable Siphon.

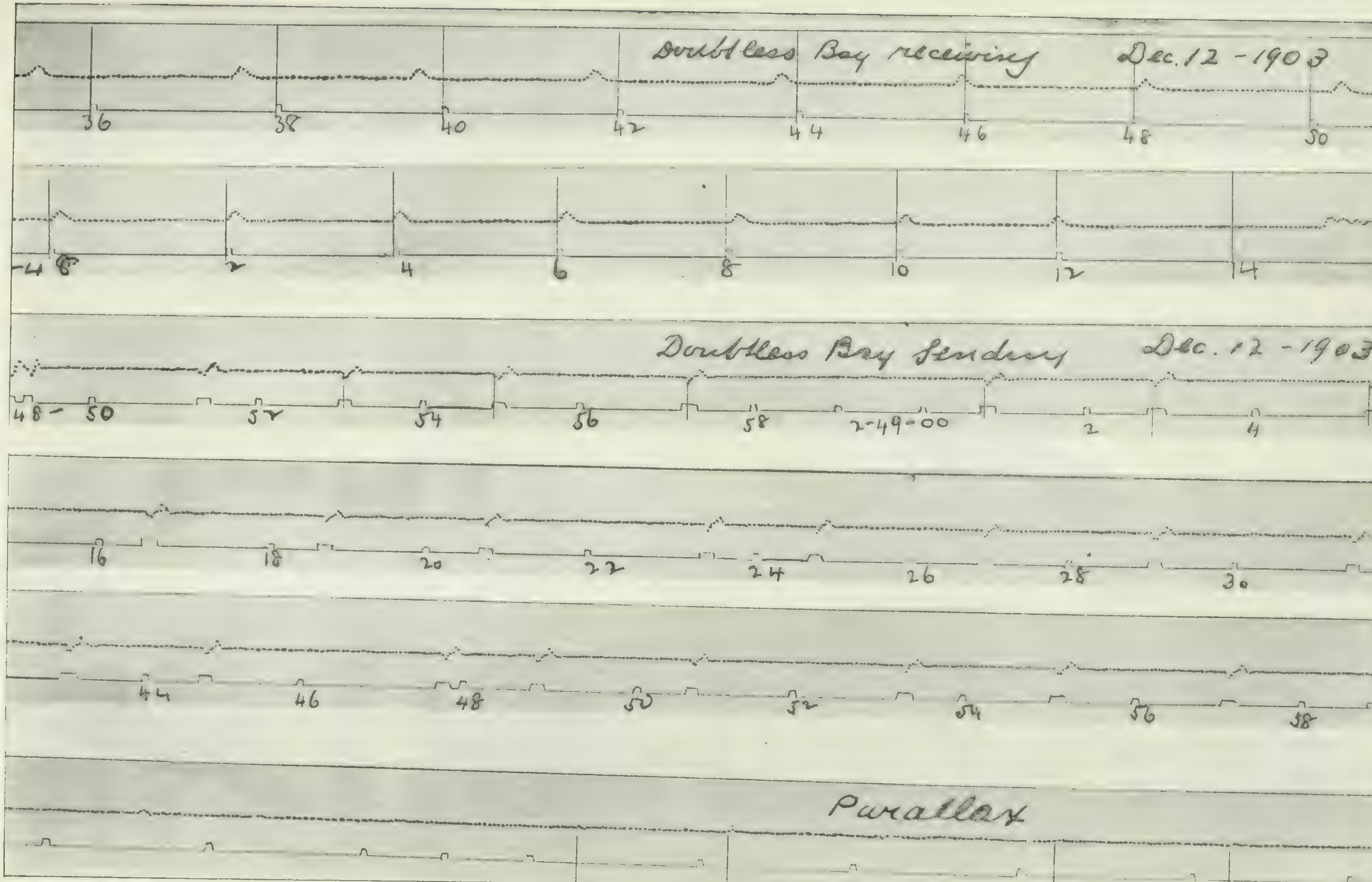


Fig. 5.—Comparison of Chronometers by Cable.

ELECTRICAL CONNECTIONS AT WELLINGTON OBSERVATORY

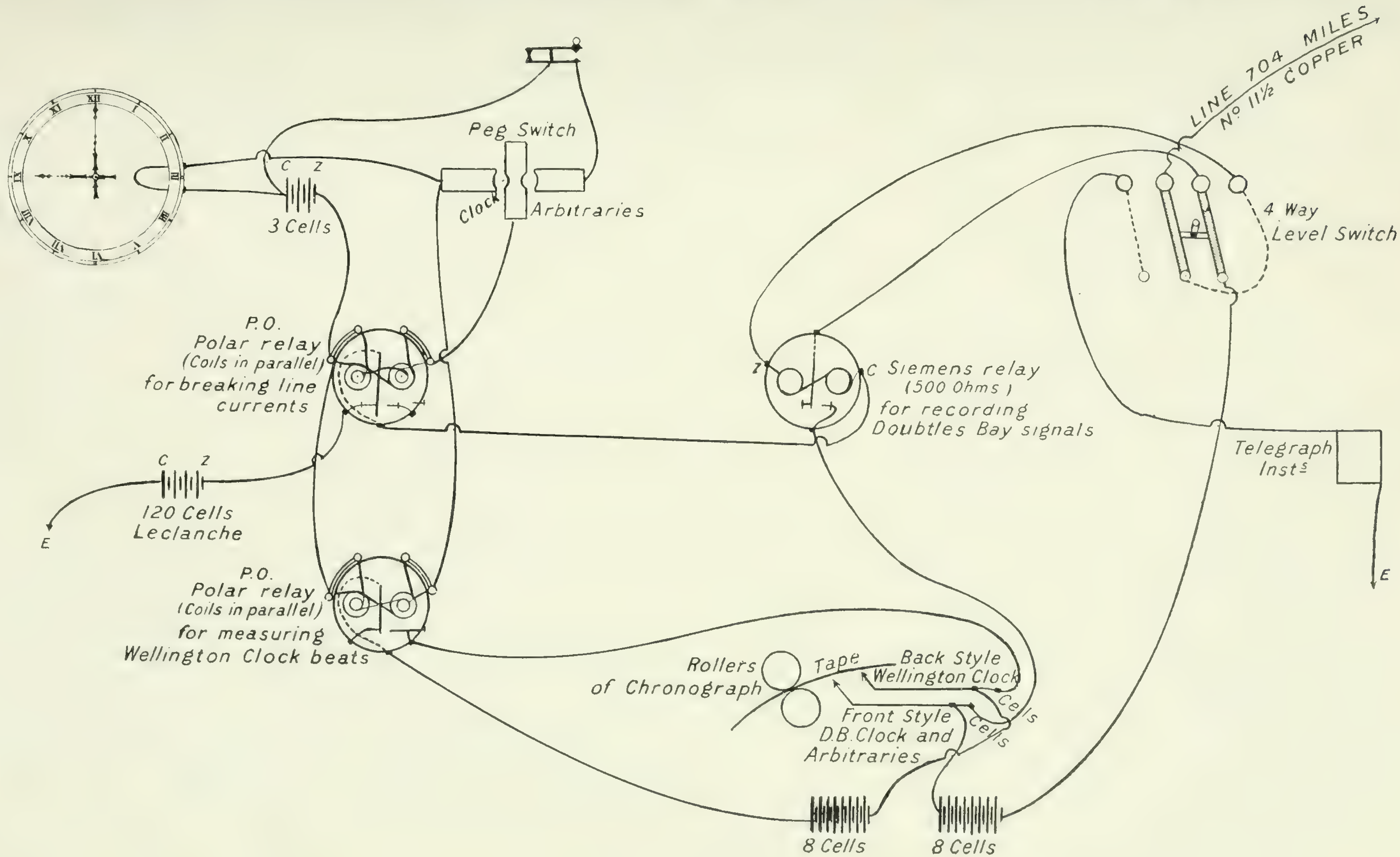


Fig. 6.

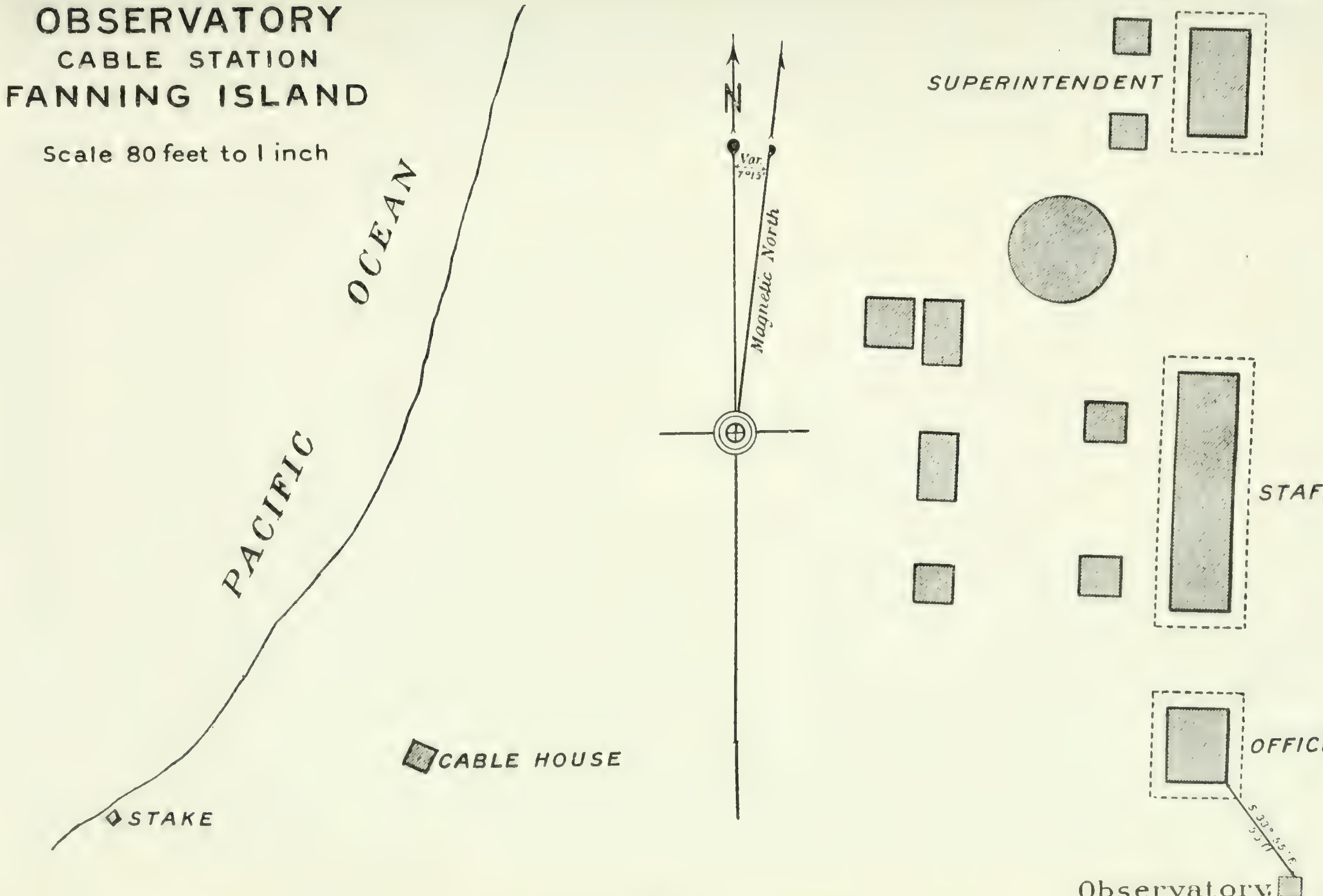

OBSERVATORY
CABLE STATION
FANNING ISLAND
Scale 80 feet to 1 inch
PACIFIC OCEAN
STAKE
CABLE HOUSE
N
Var. 7°15′
Magnetic North
SUPERINTENDENT
STAFF
OFFICE
S 33° 55′ E
55 ft
Observatory

Fig. 7.

Photo by Otto Klotz

Fig. 8.—Observatory at Suva, Fiji.

OBSERVATORY
CABLE STATION
SUVA, FIJI

Scale 80 feet to 1 inch

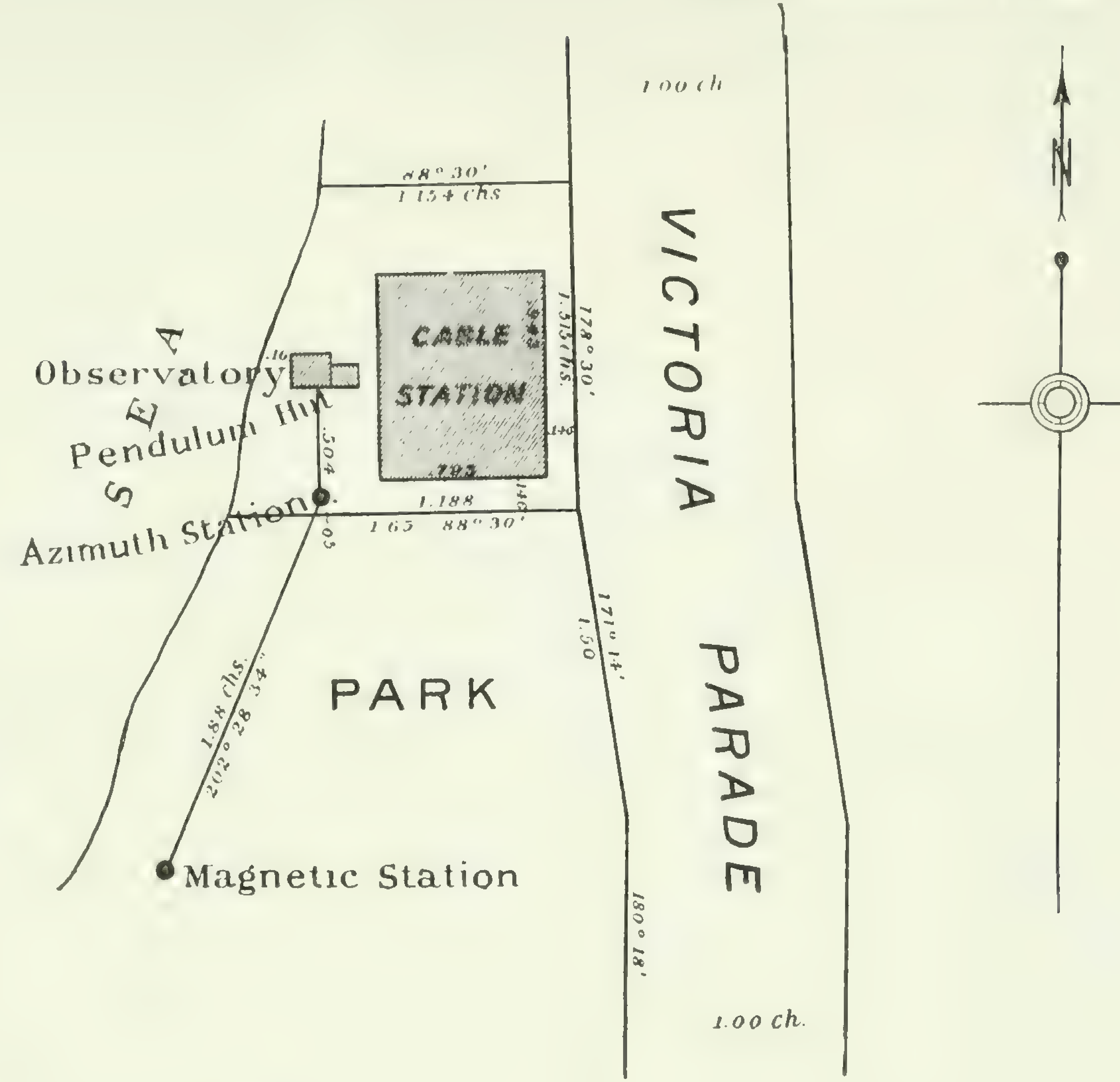


Fig. 9.

Fig. 10 Pacific Cable Station, Suva, Fiji.

Photo by Otto Klotz.

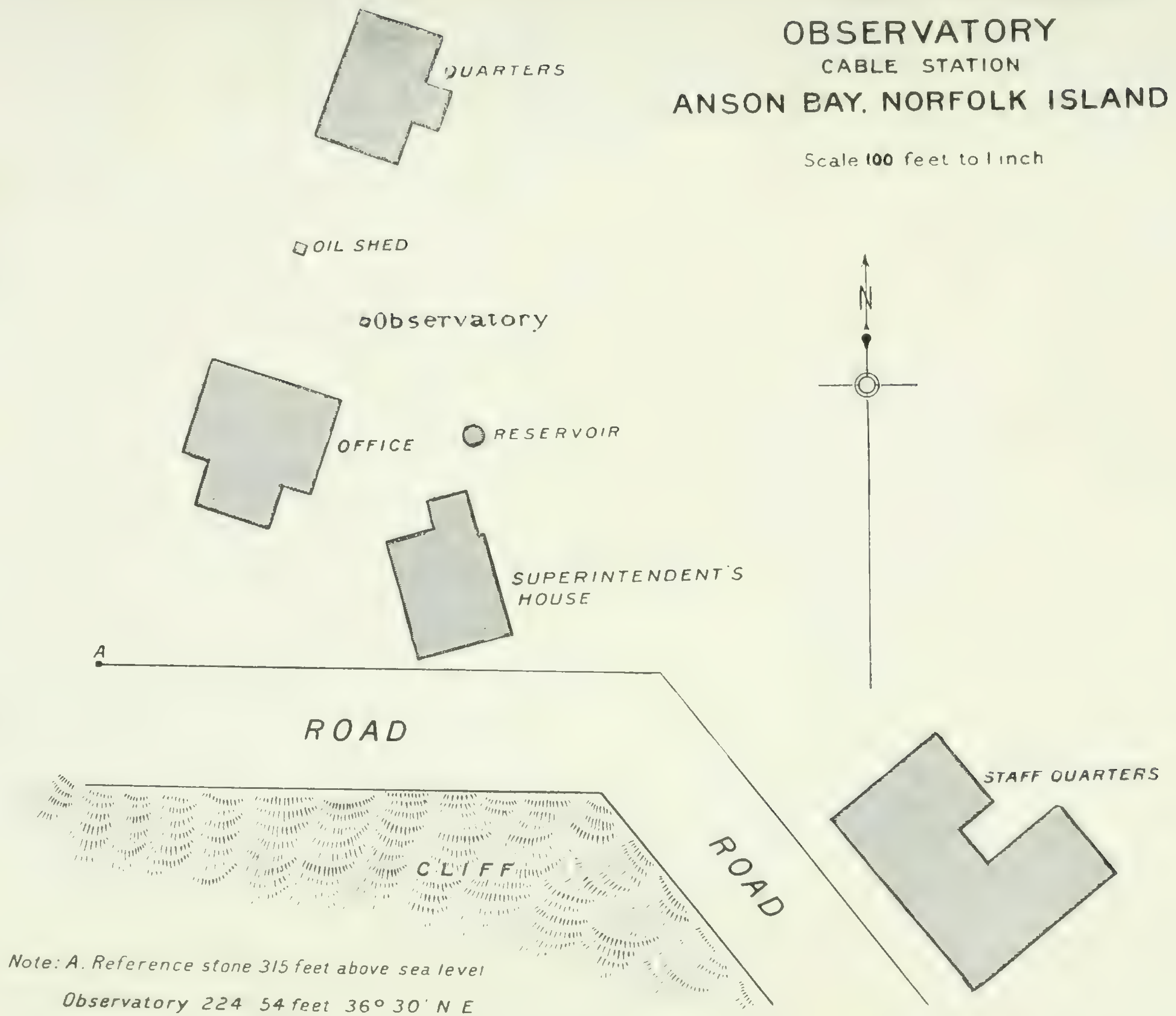
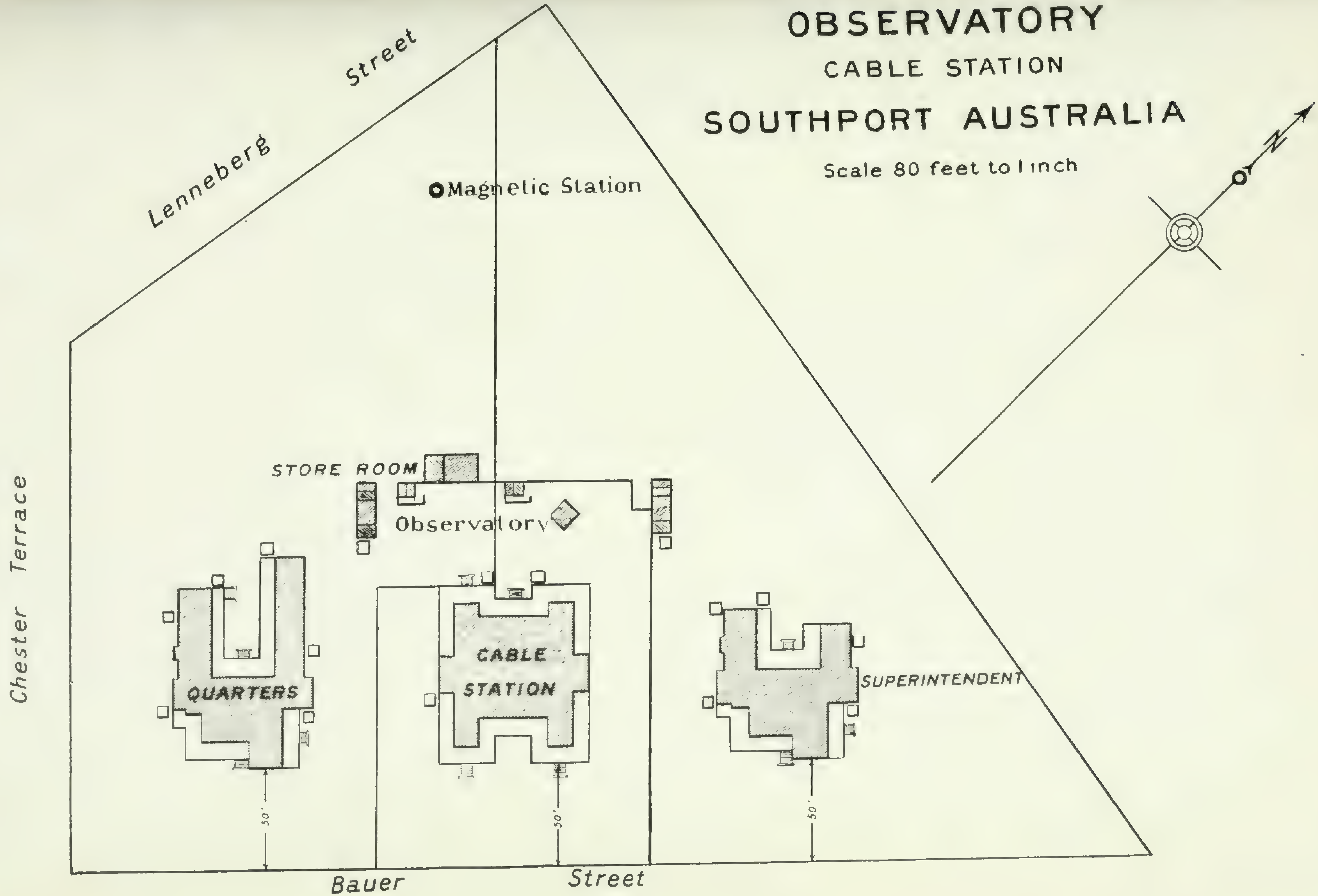

OBSERVATORY
CABLE STATION
ANSON BAY, NORFOLK ISLAND
Scale 100 feet to 1 inch
N
QUARTERS
OIL SHED
Observatory
OFFICE
RESERVOIR
SUPERINTENDENT'S HOUSE
A
ROAD
ROAD
STAFF QUARTERS
CLIFF
Note: A. Reference stone 315 feet above sea level
Observatory 224 54 feet 36° 30' N E

Fig. 11.

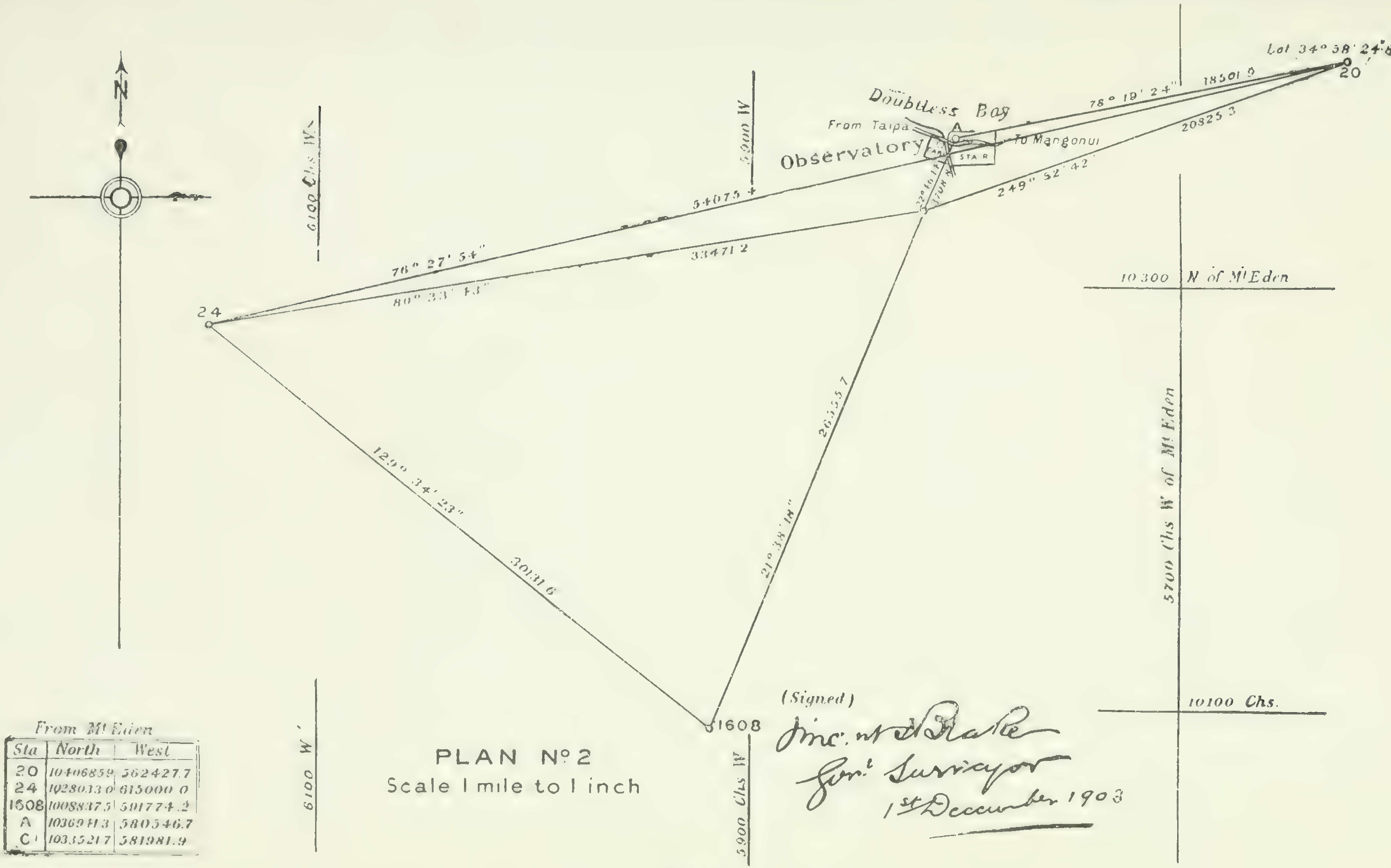


OBSERVATORY
CABLE STATION
SOUTHPORT AUSTRALIA
Scale 80 feet to 1 inch
N
Lenneberg Street
Magnetic Station
STORE ROOM
Observatory
QUARTERS
CABLE STATION
SUPERINTENDENT
50'
50'
50'
Chester Terrace
Bauer Street

Fig. 12.


DOUBTLESS
BAY
N
Lat. 34° 58' 48".34
P
Pendulum Station
From Taipa
283° 36' 56" True
282° 51' 14"
6.28 chs
Road 1 chain wide
Lat 34° 58' 49".26
A
78° 19' 24"
79° 05' 06" True
Magnetic Station
CABLE
STATION RESERVE
4.905 chs.
37088
CABLE
STATION
PLAN No. 1
Scale 80 feet to 1 inch
249° 37' 24"
250° 23' 06" True
Observatory
Lat 34° 58' 50".37
To Mangonui
35 ac 3 r. 28 p
From C 22° 48' 14"
23° 31' 56" True
OBSERVATORY
CABLE STATION
DOUBTLESS BAY, NEW ZEALAND

Fig. 13.



Sta	North	West
20	10406859	562427.7
24	1028033.0	615000.0
1608	1008837.5	591774.2
A	1036941.3	580546.7
C	1033521.7	581981.9

Fig. 14.

APPENDIX 4

REPORT OF THE CHIEF ASTRONOMER, 1905.

OBSERVATORY BUILDING

AND

INSTRUMENTAL EQUIPMENT

BY

J. S. PLASKETT, B.A.

CONTENTS

ILLUSTRATIONS.

APPENDIX 4.

OTTAWA, CAN., October 31, 1905.

W. F. KING, Esq., B.A., LL.D., D.T.S., &c.,
Chief Astronomer,
Department of the Interior,
Ottawa.

SIR,—In accordance with your instructions, I submit herewith a description of the observatory building, electrical installation and instrumental equipment.

I have the honour to be, sir,
Your obedient servant,

J. S. PLASKETT.

DESCRIPTION OF BUILDING.

The observatory building, recently completed, and occupied by the staff of the astronomical branch since April, 1905, is situated on the Central Experimental Farm. The site is near the north gate of the farm, about half a mile northwest of the farm offices, and is two miles and a half south southwest from the parliament buildings.

The building itself, which is constructed in a very substantial manner of grey sandstone with red sandstone trimmings, consists, as the plans and photographs show, (see figs. 1 to 6) of a central octagonal-shaped tower surmounted by a revolving hemispherical dome, which forms the covering for the equatorial telescope. The wings on each side of this tower recede at an angle of 15 degrees, and the one to the left or west side faces due south. The transit house, an extension of the west wing, one story in height, and now in course of construction, is for the purpose of housing the meridian circle and transit instruments used for the determination of time, longitude and star positions.

On entering the main door, which is surmounted by a fine coat of arms, carved from the red sandstone, one passes either to right or left around a circular wall of pressed brick which encloses, but is entirely separated from, the circular concrete pier, 9½ feet in diameter, which rises, from a stone foundation below the basement, nearly to the floor of the equatorial room, and forms the support for the telescope. The central hall, directly to the north of the circular entrance hall, leads east and west by corridors, to the rooms and offices in the wings, while the main staircase, of iron with slate treads rises to a landing and from thence back to the first floor. All the corridors and halls are faced with pressed brick and paved with tile, and the whole building is of a thoroughly fire-proof construction.

In the east wing on the ground floor the director's room, at the southeast corner of the building, overlooking the farm and the city, is very conveniently situated, being directly across the corridor from the library and reading room, and communicating with the secretary's (Mr. Simpson's) office, which in turn opens into the messenger's room, where the stationery supplies are kept. The reading room, in which the principal astronomical and scientific periodicals are kept on file, opens into the library which is fitted with steel bookcases with adjustable shelves and sliding plate glass doors.

In the west wing, besides an astronomer's (Dr. Klotz's) and computing offices, is the time service room in the northwest corner of the building. The switch-board and appliances, from which the electrically actuated dials not only in the observatory but

in the central and departmental blocks are controlled and regulated, are placed in this room which opens through a small room used for chronographs into the transit house. The whole instrumental equipment for maintaining and communicating standard time, which is fully described in another section of this report, is thus controlled from this room, while the time itself is determined in the transit house entered from this room through the chronograph room where the transits are recorded. The transit house, which is now approaching completion, has piers for two transit instruments, the westerly one, provided with subsidiary piers for collimating telescopes, is to hold the standard transit instrument, the easterly one to be used for the field instruments in determining personal equation. Beyond the transit instruments, in the westerly section of the building, a 6-inch meridian circle by Troughton & Simms is to be installed.

Proceeding to the first floor by the main staircase in the central hall a somewhat similar plan, corridors running east and west, is here met with. To the south of the central hall is the staircase leading to the midway and equatorial floors, and directly over and of the same shape as the entrance hall is a circular room fitted with concentric steel cases for the storage of instruments and apparatus. In the west wing on the south side of the corridor is a large room extending the whole length of the wing intended for public lectures and demonstrations on astronomical and scientific subjects. Water supply and electrical connections are provided with a view to convenience in arranging experiments and demonstrations. A large draughting room at the end of the corridor has provision for the storage of the various maps and plans used in connection with boundary surveys.

In the east wing besides a draughting room, an astronomer's (Mr. Plaskett's) and the chief computer's (Mr. Macara's) offices, is the photographic room, at the end of the corridor and extending across the whole width of the wing. A large skylight at the north end of the room gives light not only for printing purposes but also to a 16-inch by 20-inch copying camera placed on casters so as to be readily wheeled to the most evenly lighted position. The dark and enlarging rooms are placed overhead in the southerly half of the room, and are reached by a stairway on the west side. The ceiling of the photographic room is of sufficient height to allow about 7½ feet headroom in these rooms, and 6½ feet in the space below, which is not partitioned off from the rest of the room, and is used for the storage of negatives, for printing when direct sunlight is required, for mounting and other purposes. The enlarging room to the south is fitted with cameras for enlarging and reducing by either day or artificial light. The dark room is entered from the enlarging room, has four large sinks for developing and washing purposes, benches, shelves, cupboard and all the necessary appliances for working plates and paper up to 30 inches by 40 inches in size.

The central tower and a square portion behind it to carry the stairs and landings are the only parts of the building rising above the first floor. The midway floor is on the same level as the roof of the main building which is flat, of tar and gravel, and surrounded by a stone parapet. The roof is of such a solid construction that many observations may be conveniently conducted upon it and the instruments, when not in actual use, may be carried into the midway floor landing.

A circular room, like the instrument room and directly above it, is reached from this landing and has a small room at the north partitioned off and fitted with sink and shelves for use as a dark room for developing the plates used in the photographic and spectroscopic attachments of the equatorial telescope. At the west side is a large tank for storage of water, while the south and east are occupied by a concave grating spectroscope placed on stands of such height as to use sunlight reflected through the south window by a heliostat placed on the balcony outside.

The circular form of the telescope pier is changed at this floor level to a rectangular section about 5 feet by 7 feet and capped by a stone 10 inches thick upon which at the ceiling level rest the adjusting blocks and column of the telescope. The circular surrounding wall also ends at the same level, and the floor of the equatorial room above

is supported by eight iron columns. The space between these columns and the rectangular pier is to be used for the storage of astronomical negatives.

The equatorial room directly above is also circular in shape, about 30 feet in diameter, and is covered with a hemispherical dome which revolves on a circular track 9 feet above the floor, laid on and securely bolted down to the stone walls. The dome, which is constructed of steel ribs covered with wood and sheathed with copper, is built upon a rigidly braced steel ring, to which the running gear is attached (as shown in figs. 8 and 9) and is easily turned by pulling an endless rope running over a pulley, geared to the turning mechanism. The shutter which is in two halves opening apart, and which extends from the bottom to about ten degrees beyond the zenith, giving an opening 5 feet wide, is also easily opened and closed by another endless rope, which causes wire cables to roll the halves apart or together on rails at the top and bottom. The room is lighted by ten windows, five each to the east and west, the south being occupied by the tower clock and the north by the stairs and two cupboards for the storage of accessories to the telescope.

In the basement which only remains to be described are some rooms worthy of mention. The clock room to the north of the telescope pier is in no part nearer than 10 feet to the external walls and is therefore well adapted for being maintained at constant temperature, a necessary provision for accurate time-keeping. In this room are the standard sidereal and mean time clocks which, as before stated, can be compared and controlled from the time service room. In the other sections of the annulus around the pier is a room for pendulum observations and the determination of gravity, and another for the storage and rating of chronometers. The workshop situated in the east wing contains a motor generator furnishing power to run the machine tools and to convert alternating current into direct current for charging accumulators and for experimental work. The switch-board, besides the motor generator (both shown in fig. 7), controls the lighting, experimental and battery charging circuits, but the electrical installation and the machine tools will be more fully described later on. The battery room in the west wing contains a large cupboard for the storage batteries, and a switch-board for connecting any of the batteries to any circuit. Beyond this is a small chemical laboratory and, in the corner under the time service room, a room for solar research.

The tube of a coelostat reflecting telescope to be shortly installed will come underground from the concave mirror 80 feet north to form a large image of the sun just outside the room, where it can be photographed or examined with powerful stationary spectroscopes. The seismograph room is in the centre of this wing, and like the clock room entirely away from outside walls, while the other two large rooms are to be used for standards and for experimental purposes. A passage way under the vestibule at the end of the wing leads from the two corner rooms either outside or to a room under the transit house which is to be used for the storage of the heavy field instruments and their cases.

ELECTRICAL INSTALLATION.

The building is supplied with electricity for light and power from the alternating current mains of the Ottawa Electric Company. A large transformer on a pole about one hundred feet north of the building reduces the potential to 104 volts. The current is carried from the transformer, in a lead covered cable, underground into the workshop and thence to a large double pole switch at the bottom of the switchboard. Here it is subdivided into three branches, each having a meter in circuit and controlled by a switch, one leading to the motor generator, and the others to the main lighting circuits.

The lighting and experimental wires throughout the building are carried in iron armoured conduits installed in a substantial manner and arranged for the easy drawing in of new wires or the withdrawal of any circuit needing repairs. Lights in all

the rooms are controlled by press button switches placed near the doors in a most convenient position. Many of the rooms also have double pole knife switches, with binding post terminals, attached directly to the mains for power, heating, or projection purposes.

The motor generator (fig. 7), made by the Westinghouse Company, is of 7½ K.W. capacity, the generator being wired to supply 60 amps. at 60 to 90 volts. The induction motor controlled by the switch to the left of the board is directly connected to the generator by a simple clutch coupling which can be readily thrown out of gear when the generator is not required. The mains from the generator lead through a Weston Station ammeter and a double pole switch on the front, to bus bars at the back of the board, and from these bus bars three branch circuits are run, one for experimental purposes and two for charging batteries. The experimental circuit, controlled by a switch on the front of the board, has a large adjustable rheostat from 0 to 100 ohms, and with a current carrying capacity of 60 amperes inserted in series with it and runs to double pole switch terminals in the rooms where it is likely to be used. In any of these rooms direct current may be obtained of any desired strength to 60 amps. and at potentials up to 90 volts. Each of the two battery circuits are also controlled by a switch and have an adjustable rheostat of suitable capacity in series with them. They proceed directly to the battery room, and are connected with the storage battery terminals, one to the small cells charging current 4 amperes, and one to the large cells charging current 20 amperes. A Weston volt-meter range 0 to 100 volts is placed in the upper right hand corner of the switch board and arranged with a four-point contact switch to give, as desired, the potentials of: 1, the generator; 2, the experimental circuit; 3, the large batteries; 4, the small batteries. Hence, in order to charge the batteries, it is not necessary to leave the workshop as the current and voltage can be read from the switchboard instruments. In addition, a recording volt-meter in circuit with the lighting mains gives a continuous record of the variations in the voltage, while a ground detector serves to give notice of any leak in the circuits. The arrangement of the switchboard is clearly shown in fig. 7.

The storage batteries are contained in a ventilated cupboard with glass doors and sides. The battery jars are placed on strips of plate glass, inserted on edge into wooden shelves. There are installed in this cupboard 50 type C 7 chloride accumulators, capacity 35 ampere hours, used for the time service, and 20 type E. 9 chloride accumulators, capacity 200 ampere hours, for experimental purposes. The switchboard directly opposite the battery cupboard is arranged so that any single cell or any number in series may be connected to any desired circuit, the small cells to the time service circuits and the large cells to six experimental circuits proceeding from knife switches on the board to the rooms where the current is likely to be used.

A very convenient intercommunicating telephone system is also installed in the observatory. Telephones in every important room have each a small switchboard attached with press buttons for every other telephone. All that is necessary in order to converse with any one is to press the corresponding button which will connect your telephone with his and ring his bell. The act of hanging up the receiver automatically disconnects the telephones. Moreover any other pair in the system can be used at the same time without interference.

INSTRUMENTS.

The Equatorial Telescope.

The objective of the telescope, of 15-inch aperture and 19 feet focus, was made by the Jno. A. Brashear Co., of Allegheny, Pa., while the mounting was constructed by the Warner & Swasey Co., of Cleveland, Ohio. The objective was designed by Dr. Charles S. Hastings, of Yale University, and differs from the usual type of telescope objective in having the flint element in front of the crown. One advantage of this type, besides the optical advantages claimed by the makers lies in the fact that flint glass

is much less susceptible than crown to atmospheric influences, and much less likely to have moisture condense upon the surface. The mounting is of the same type as that used by Warner & Swasey in the Washington, Lick, and Yerkes refractors, which has proved so satisfactory in every respect. A description of the mounting and method of operation of the telescope will properly come first and be followed by a description of the accessories.

Two plates provided with screws for adjustment of the column in altitude and azimuth rest on the stone cap at the top of the pier about 8 inches below the floor level, and on these plates rests the hollow iron column of the telescope. This column which is in two sections as shown in figs. 8 and 9, tapers up from the base in graceful curves, ending, in the upper section, in straight lines. It is about 5 feet by 3 feet at the base and 2 feet 4 inches by 1 foot 1 inch at the top, and 9 feet high. The upper section of the column serves as clock case, access to which is given by a glass door at each side, while a door in the lower section admits to the clock weights which descend inside. The column is capped by the polar head (fig. 10), a substantial casting of neat and graceful design, which is bored to admit the polar axis at an angle equal to the latitude of the observatory about 45° 23′ 30″. In these bearings the polar axis turns, resting on a ball thrust bearing at the south end and having, on the north end, two steel rollers pressed up against the axis by an adjusting screw and lever. By forcing the rollers against the axis, the greater part of the pressure on the bearing surface can be relieved, and the friction consequently reduced until the axis with telescope attached turns very easily in its bearings.

The axis itself has an enlargement on its upper end to which the declination bush is firmly fastened by screws. The driving worm wheel is situated between the upper bearing and the bush and is loose on the slow motion sleeve, being clamped to it when required by a V-shaped block forced into a groove turned in the sleeve by a screw, connected by gearing in the declination bush with the right ascension clamp and slow motion rod on the side of the tube. Between the bearings on the polar axis are three insulated rings with brushes for transferring the illuminating current from the stationary to the moving parts, a large bevel gear for moving the telescope in right ascension by the hand wheel seen on the north of the column, and the hour circle, containing both coarse and fine graduations, the coarse to 5 minutes on the outer edge of the rim, and the fine on the lower side reading by two verniers to 2 seconds. These verniers are read through the two telescopes projecting out of the north end of the column above the dial and hand wheel, the light being carried down through the tubes by reflecting prisms to the telescopes below.

The declination bush is hollow, carrying the declination axis, which is enlarged at one end, like the polar axis, to carry the telescope tube. The axis ends before reaching the coarse declination circle which is fixed to the bush, the pointer being moved by means of intermediate gearing from the end of the axis. The fine declination circle is on the outer edge of the wheel seen close to the tube and the declination is read from the verniers to 30 seconds of arc through the two tubes above and below the telescope tube and extending down to the eye end. By this convenient arrangement of reading telescopes the hour angle of the telescope is read from the end of the column, where it is moved in right ascension, and the declination is read from the eye end where it is moved in declination. The clamp and slow motion in declination, worked from the smooth pair of knots on the inside of the telescope tube acts in the same way as the right ascension mechanism, having corrugated knobs, by forcing a V-shaped block into a groove turned in the axis. The clamp in both cases is actuated by the smaller knob which turns a steel rod inside the brass tube which is itself turned by the large knobs, and controls the slow motion mechanism, whose action will be readily understood from fig. 10.

The telescope tube, whose construction is also shown in the illustrations, consists of a central section of cast-iron 18 inches in diameter and 12 inches long, firmly screwed to the declination axis. A flange at each end of this section is firmly screwed to two brass flanges in which the eye and objective sections end. These sections 17

inches in diameter, are constructed of sheet steel $\frac{3}{16}$-inch thick in lengths of 2 feet firmly riveted together forming a rigid and comparatively light tube about $17\frac{1}{2}$ feet long, the eye end being 6 feet and the objective end $10\frac{1}{2}$ feet long. A brass flange is screwed to the upper end for holding the objective and a cast-iron collar firmly screwed to the eye end serves to hold the telescope tail piece into which the different attachments screw. This tail piece, made of brass, is held by four capstan headed screws, and allowance for collimation adjustment is provided by four abutting screws through the collar. A hole through the tail piece $8\frac{1}{2}$ inches in diameter is threaded and then sections of the thread milled out; the corresponding male threads on the eye-piece adapter, the spectroscope adapter, and the solar camera, all of which are interchangeable in the tail piece, are treated in the same way, the result of the process being called, technically, a quartered or mutilated screw. To attach any of these pieces all that is necessary is to insert them into the tail piece, push home, and give an eighth turn which clamps them rigidly in place, unscrewing being prevented by a small pin going through the side of the tail piece, and caused, by a spring, to enter a hole in the attachment. Detachment is effected by lifting the pin, turning back one-eighth revolution and then pulling out. If the screw were complete not only would the pieces be more difficult to enter, but six or seven revolutions instead of one-eighth would be required.

The two finding telescopes, one of $2\frac{1}{2}$ inches, and the other of 4 inches aperture, are fastened to the outside of the tube by adjusting screws to admit of their axis of collimation being made parallel to that of the telescope. The eyepieces, which have cross-wires of fairly coarse wire, large enough to be visible without artificial illumination, are brought down to a convenient position, somewhat lower than the tail piece, but above the main eyepiece. Between the finders are two steel rods, screwed to the tube, carrying counterweights weighing 12 pounds each, which can be removed or added to, according to the attachment in use, to balance the tube in declination. For instance when the spectroscope is attached all the counterweights have to be removed, as it is not only much heavier than the eyepiece or micrometer, but extends beyond the focal plane. The telescope is balanced in right ascension by large weights, about 50 pounds each, screwing in and out on an extension of the declination bush so that the necessary balancing of the telescope in both directions can be readily accomplished.

The driving clock (fig. 11) which is contained in the upper section of the column, to which access is had by glass doors on each side, is of the regular type of conical pendulum clock built by Warner & Swasey. The governor balls are bored slightly out of the centre so that, by turning on their axes to a graduated scale, the effective length of the arms and consequently the rate of the clock is varied. When the speed of the balls approaches the limit, they rise from their position of rest and cause small fibre friction pads to rub on a circular brass cylinder attached to the top of the case, concentric with the spindle. The motion of the governor spindle is communicated by a train of reducing gears to the connecting rod, shown going up through the column, which in turn by a pair of mitre gears turns the worm, which gears into the driving worm wheel on the polar axis. The clock also drives, by another train of gears shown at the right of the figure, the setting circle shown on the north side of the telescope column. This consists of two concentric circles divided each into 24 hours, and each hour into 5 minute divisions. The outer circle, fixed to the column, has the 24-hour division at the top, while the inner circle turns with the clock, one complete revolution in 24 hours, by friction only so that it can be set to any desired position. The pointer of celluloid with vernier reading to minutes extends across both circles, and is attached by an independent train of gears to the polar axis. It indicates the hour angle of the telescope by its reading on the outer circle, while the inner circle shows the sidereal time. In order to set this circle correctly, when the clock is started, all that is necessary is to move it until the reading opposite 24 hours or 0 hours on the outer circle corresponds to the sidereal time at the instant of setting; or if the sidereal time is not known, turn the telescope to bring any star of known right ascension in the centre of the field and then set the dial so that the pointer shows this right ascen-

sion. After this setting is made, any star above the horizon can be brought into the field, after setting the telescope in declination, by turning the telescope by the hand wheel below the dial until the pointer indicates its tabular right ascension. All mental arithmetic and many mistakes are avoided by this simple and useful device, which answers, with the use of the coarse declination circle, for all ordinary finding purposes. The closer readings given by the verniers on the fine declination and hour circles will only be required for adjusting the telescope and similar purposes.

These readings are obtained as before stated through reading telescopes conveniently situated near the places where the separate movements are given. For work at night each vernier is illuminated by a small electric lamp which is part of a system of electric illumination fitted to the telescope. In addition to two lamps each at hour and fine declination circles, there are two at the coarse declination circle, one above the setting circle, a hand lamp at the eye end for reading the position angles of the micrometer and spectroscope, and a lamp for illuminating the wires or field of the micrometer. The wires are led up through the column, and the current is carried to the moving parts by brushes bearing on insulated rings on the polar and declination axis. A three-point switch below the setting circle controls its lamp and those of the hour and coarse declination circles, while the switch for the fine declination circle is at the eye end convenient to the reading telescopes.

The whole arrangement of moving mechanism, finding circles and electric illumination is extremely convenient and complete, while the whole mounting is constructed in the best possible manner, is a credit to the makers, and very much facilitates working with the instrument.

Telescope Accessories.

Eye-piece Adapter.

The eye-piece adapter (shown in fig. 8), which is fastened into the tail-piece of the telescope by an eighth turn of its quartered screw, has a concentric inner tube 4½ inches in diameter, moveable for adjustment to focus through a range of 9 inches by a rack and pinion. There is another quartered screw in the end of this tube 3 inches in diameter into which the micrometer and the attachment for eye-pieces, &c., fasten; while in the eye-piece attachment a second tube 2½ inches in diameter slides, into which the eye-piece tube, the solar attachment, and the registering photometer can be screwed.

Six Huyghenian eye-pieces fitting either into the eye-piece tube, the diagonal prism, or the solar attachment are supplied, with powers ranging from 125 to 750. The solar attachment is provided with a reflecting polarising arrangement, and the intensity of the image can be varied at pleasure by rotating the outer end. A wide angle eye-piece, with a power of 110, but giving a considerably larger field than the lower power eye-piece, is also provided and it screws into the same slip tube as the solar attachment. Further a diagonal prism into which the eye-pieces can be placed is also provided for convenience of observations near the zenith. The eye-pieces and photometer are clearly shown in fig. 12.

The Photometer.

The photometer, for the determinations of star magnitudes, was designed and made by Brashear and is of the wedge pattern, with a registering attachment. The essential part of the instrument is the wedge-shaped strip of dark glass, which can be moved back and forward under the eye-piece by a quick-acting rack and pinion. The amount of light absorbed by the glass depends upon its thickness, which, of course, varies directly with its distance from the thin end. The photometer is used by comparing the position on the wedge, and consequently the thickness of the dark glass, at which the light from stars becomes completely extinguished. This would have to be

done, were it not for the registering attachment, by turning on the light and reading a scale between each observation. This not only takes considerable time, but also diminishes the accuracy of the observations by causing a change in the condition of the observer's eye. A reference to fig. 12 shows a rotating cylinder with a pencil above it arranged to mark on a strip of ruled paper fastened around the cylinder. When the wedge has been moved to the extinction point, a pressure on two keys causes the cylinder to move through a fortieth of a revolution, and, at the same time, presses the pencil on the paper, making a mark. The observation can be repeated and another mark made, or the telescope pointed to another star and another series of observations taken, all very quickly and without turning on the light. The whole sheet, forty readings, may be filled at one time or only a few taken as desired. The observations are readily taken from the sheet, which has a printed scale similar to the scale on the wedge, and the mean of any series easily obtained.

The Position Micrometer.

This is a very complete instrument (fig. 13) by Warner & Swasey, of the same type as that made by them for the Yerkes and Lick observatories. It is furnished with five positive eye-pieces, giving powers ranging from 200 to about 500, and with three dark glasses for solar work. It is furnished with electric illumination of field or wires, the contacts being automatically made when the micrometer is inserted, by means of an eighth turn of its quartered screw, into the eye-piece adapter. The change from the illumination of field to that of wires is made by simply turning a knurled knob, while the light can be made any desired colour by rotating a diaphragm. There is the usual arrangement of one fixed and one moveable vertical wire and a horizontal wire. The micrometer head can be moved from one side to the other by a long screw knurled at each end, while another quick-moving screw permits the eye-piece to be moved with respect to the wires. The distance between the vertical wires is read off on a large micrometer head graduated to hundredths, and readily estimated to thousandths, while the number of revolutions of the head is read off on a dial beside the head. The position circle is graduated on silver to half degrees, and is read to five minutes by two verniers. The instrument is arranged so that micrometrical work can be done with the greatest ease and convenience.

The Solar Camera.

The solar camera made by Brashear and shown beside the telescope column in fig. 9, is attached to the tail-piece of the telescope by an eighth turn of its quartered screw, in the same way as the spectroscope and eye-piece adapters. A negative lens of 3½ inches aperture and 30 inches focus is placed within the focal plane, and forms an enlarged image of the sun about 6½ inches in diameter, 42 inches beyond the focal plane. The camera part, which is connected with the lens by a conical tube of thin sheet metal, is intended for 8 by 10 plates. The lens as well as the camera back is adjusted to focus by a rack and pinion. The exposing shutter for solar work consisting of a narrow adjustable slit in a metal plate, is placed about one-third the way down from the lens, and is drawn rapidly across the beam of light by a spring. If desired to use the camera for the moon or other celestial objects, this shutter can be entirely removed and exposures made by a cap on the enlarging lens, opened and closed by a rod extending down the camera tube. The camera extends nearly 5 feet beyond the tail-piece, but is light enough to be well within the range of counterweights provided for the telescope. In fact it does not disturb the balance so much as the spectroscope which requires the removal of all the weights from the eye end and a considerable change in the balance in right ascension.

The Spectroscope.

The universal spectroscope, also by Brashear, is of a similar design to those, by the same maker, of the Allegheny and Lick observatories, and is designed for general spectroscopic work. The general design and arrangement of the spectroscope, when used with the train of three prisms, is shown in fig. 14, while the other accessories are seen beside it. The spectroscope is attached to the equatorial by the adapter, consisting of a cylindrical sleeve with a quartered screw fitting into the telescope tail piece and fastened by an eighth turn. A collar, to which are attached two tubes 31 inches long and 1$\frac{3}{16}$ inches in diameter, parallel to and equidistant from the axis, rotates upon the sleeve while a graduated circle allows it, and consequently the spectroscope, to be set to any required position angle. The frame of the spectroscope is attached in any desired position to the two tubes by four hinged clamps. The collimator tube passes through the frame of the spectroscope midway between the adapter tubes, and consequently in the optical axis of the telescope. It moves by rack and pinion longitudinally through a range of adjustment of 2 inches, and its position can be read on a millimetre scale.

The slit at the front end of the collimator tube has jaws of speculum metal, highly polished, and inclined slightly, so that light from a star may be reflected back, and to one side, out of the way of the incident light, into a telescope, forming an efficient means of guiding or keeping the star image on the slit. The slit jaws are moved apart by a screw forcing a cone between them, and are brought together by a spring, and the head of the screw is graduated indicating slit openings of thousandths of an inch. A diaphragm constructed like that used by Hartmann at Potsdam is placed close in front of the slit. It moves in a slide between adjustable stops so that any desired width of star and comparison spectra may be taken on the plate. It may readily be removed so that the whole length of the slit is unobstructed, or other diaphragms with any desired arrangement of apertures may be inserted in its place. The length of the slit can also be limited by two metal plates behind it, and the whole slit mechanism is fastened in a tube sliding within the collimator tube and focussed by rack and pinion, the position likewise being read off on a millimetre scale.

The collimator is supplied with two triple cemented objectives of 1$\frac{1}{4}$-inch aperture and 15 inches focus. They were specially computed by Hastings, one being corrected for the Hγ region, to be used for radial velocity work with ordinary plates, and the other for the region around λ5600 to be used with orthochromatic plates and for visual purposes.

The three prisms in the prism train are of medium dense flint, index for Hγ about 1·64, and they give excellent definition. They are mounted on a minimum deviation device so that they may be used on any part of the spectrum, but are specially intended for the Hγ region. They are of such a size as to transmit undiminished the parallel beam of light from the collimator. The semi-circular brass box, in which they are contained, has screws passing down through its cover which may be used to exert pressure on the top of the prism cells, and prevent any movement during the long exposure required on stellar spectrograms. The prism box is rigidly fastened to the prism table and to the frame of the spectroscope, and the camera which screws into the end of the minimum deviation train by a quartered screw is braced by a pair of rods clamped firmly to it and to the frame, further stiffening the prism box and making the whole instrument thoroughly rigid, a prime necessity in line of sight work.

The camera, like the collimator, has two triple objectives of 1$\frac{1}{4}$-inch aperture and 15 inches focus corrected for Hγ and λ5600. They are focussed by means of a rack and pinion and the position can be read off on a millimetre scale. The camera tube, which is of large diameter, is thoroughly diaphragmed and has a tilting back adjustable to any required inclination. The plate holders, four in number, of metal, slide into this tilting back and hold plates 2 inches by 3 inches on which a spectrum 2$\frac{1}{4}$ inches long and any width to $\frac{5}{8}$ inches may be photographed. The observing telescope screws

into the same place as the camera and has an objective of about 10 inches focus. This telescope has a micrometer attachment with three eye-pieces for measuring wave lengths, the cross wires being illuminated by a small electric lamp permanently attached to the micrometer. A diaphragm with coloured glasses admits of the light being made any desired colour.

The spectroscope is provided with two single prisms of light and dense flint indexes of 1·60 and 1·73 respectively and with a Rowland plane grating of 2½-inch aperture, ruled surface 1·25 ins. by 1·9 ins. and 15,000 lines to the inch. Either of the prisms or the grating may be placed on the rotating prism table when the prism train box is removed, being held in position by two screws and covered with adjustable covers. The camera and observing telescope are, in this case, screwed into a swinging arm pivoted concentrically with the prism table to the spectroscope frame. A double graduated circle on silver provided with verniers reading to 10 seconds of arc gives the position of this arm and of the prism stand, thus allowing the instrument to be used as a spectrometer.

Numerous other accessories are provided, chief among which are: 1. Attachment for comparison spectra which fastens to one of the tubes and swings back out of the way when not in use. It is provided with terminals for metallic electrodes and a holder for vacuum tubes. 2. A cylindrical lens for visual observations of star spectra. 3 A telescope for observing the image reflected from the slit plates for guiding during exposures on stellar spectra. 4. A similar telescope attached to the prism train which receives the light reflected from the surface of the first prism, and hence guides by the light transmitted through the slit. 5. A perforated nickel-plated disc for screening part of the sun's heat from the slit mechanism. 6. A tripod stand to hold the spectroscope for laboratory purposes and other minor accessories.

For photographing stellar spectra, a correcting lens to bring the focal points for the rays of short wave length to the same point is necessary. The telescope objective is corrected for the visual rays, and the focal points for the blue and violet light are distributed over a range of about an inch. The correcting lens of three inches aperture, placed about 36 inches inside the focal plane in a tube attached to the adapter, brings the actinic rays to the same focal point, about 2 inches inside the visual focus, and allows a long range of spectrum to be photographed on the plate, while if the correcting lens were not used only a very short portion could be obtained at once. A spectrum of Arcturus, taken with the spectroscope, and with a comparison spectrum of the iron spark on each side is reproduced in fig. 15, about three and a half times enlarged.

The Stellar Camera.

For photographing stars and nebulæ, a camera with a photographic doublet of 8 inches aperture and 40 inches focus, made by Brashear, is bolted, as shown in figs. 8, 9 and 10, to the centre of the telescope tube opposite to its place of attachment to the declination axis. It takes a plate 8 inches by 10 inches in size, and gives a circular field of 8 inches in diameter or about 11° 20′. This lens gives exquisite definition over a field of 7° or 8° and by averaging may be extended a little further. The following information regarding the type and construction of the lens is given by Dr. Brashear.

'The general construction is that which was first found by Petzval years ago, and has proven itself quite the best, where great angular aperture with sharp definition is imperative. The curves have been somewhat modified from our experience in the construction of other lenses—particularly those made for Dr. Max Wolf, of Heidelberg, Germany. It departs, however, from the ordinary practice of opticians in being corrected for short wave lengths of light. This would be quite objectless in a camera which is to be used for portraits, but is not without moment in astronomical photography. The materials employed were specially chosen for their transparency, the flint being very light and the crown very white. The focal lengths of the front and rear combinations are in a ratio of about 7 to 12, while the focal length of the system is very nearly five times the aperture. The focal length you may find very slightly

modified: indeed it is our custom to balance the inevitable zonal differences of magnification, which difficulty is found the most formidable to all constructors of astronomical photographic objectives.'

The camera itself consists of a metal tube, having at the front end an inner sliding nickelled tube containing the objective, which is focussed by a rack and pinion, and, when the correct focus is obtained fixed in position by a clamp screw. This position, which of course is obtained by trial, is read off on a millimeter scale. At the back of the camera is a metal frame into which the plate holder slides, being held down to the frame by springs. A metal shutter over the objective is actuated by a rod extending down the camera tube. The guiding is done by the micrometer wires in the telescope, and, owing to the much greater focal length of the telescope objective, it is easy to obtain accurate guiding. A photograph of a portion of the Milky Way taken by this camera is reproduced in fig. 16. The centre of the photograph is at R.A. 21 h. 32 m., $Decl^n + 49° 05'$. Exposure 6 hrs. 20 mins. The beautiful definition given by this objective is well shown in this photograph.

Cooke Equatorial Telescope.

A Cooke-Taylor 4½ photo visual objective of 81·8 inches focus is supplied with a very complete equatorial mounting by the same firm. A large and solidly braced tripod serves for the base of the instrument, which is of a portable character and so packed in boxes that it may be taken into the field with little more difficulty than a transit instrument. The equatorial head is adjustable for any latitude, and has hour and declination circles graduated on silver, and reading by verniers to minutes of arc. A powerful driving clock, which is mounted on a sub-base about half way down the tripod legs, is connected by an adjustable rod to the worm engaging in the worm wheel on the polar axis. The clock stand is connected to the three tripod legs thus bracing and stiffening the instrument. The telescope tube of brass, and lined with black velvet to prevent reflection, is in two sections for portability. It is supplied with four eyepieces ranging in power from 50 to about 250, and with dark glasses for solar observations. The eye end is readily detached by removing a pin and turning counter clockwise about 10°, and a camera back, with a focal plane shutter using a 4¾-inch by 6½-inch plate, is readily attached in its place. This is adjustable to focus and, owing to the property of the photo visual objective of bringing the photographic and visual light to the same focus, gives exceedingly fine definition for stellar or long-distance terrestrial photography. A negative enlarging lens, attaching inside the focal plane, can be used if desired, giving an equivalent focus of about 20 feet. At present the telescope is not mounted but it is proposed to place it on the roof of the observatory and protect it with a removable cover. It can then be used for stellar photography, and for visitors when the large equatorial is in use, or has the spectroscope or solar camera attached.

Laboratory Apparatus.

Induction Coil and Accessories.

An induction coil by Queen & Co., capable of giving a 15-inch spark, shown beside the telescope in figs. 8 and 9, is used principally for forming the spark spectra of the elements and more particularly for comparison spectra of the elements for radial velocity work with the spectroscope. A battery of six Leyden jars may be inserted to give more body to the spark, and to get rid of some of the air lines. Current to run the coil may be supplied either from the storage battery circuit, or from a motor generator set of 500 watts capacity. The coil is placed on a stand with casters, having a place for the condensers below, and may be wheeled about to suit the different positions of the telescope. In connection, there is also a complete set of vacuum tubes of the gases likely to be used in spectroscopic work, and a set of spark electrodes of the metals most suited for comparison spectra.

Concave Grating Spectroscope.

This instrument, which was made by Brashear, is installed at the midway floor. The grating is of 4 inches aperture and 10 feet radius of curvature, and is ruled with 15,000 lines to the inch. It is mounted in the Rowland method, which may be shortly described as follows: The grating, placed in an adjustable holder, and the camera box of the micrometer are mounted at the two ends of a braced tube the radius of curvature, or 10 feet apart. The tube with these attachments is placed on two two-wheeled carriages which are pivoted at their centres under the centres of the cameras and grating respectively. Each of these carriages has a grooved wheel at each end about 18 inches apart which run on ⊥ rails the upper edge of which is accurately planed to fit the groove in the wheel and to be perfectly straight and true. These two rails, each about 10 feet 6 inches long, are mounted on steel pillars about 5 feet high, so as to be on a level with the windows, and are placed end to end exactly at right angles to each other. At their intersection, and in the same horizontal plane as the camera and grating, is mounted an adjustable slit. The grating and camera are each placed normal to the line joining their centres. Light coming through the slit and incident upon the grating will be diffracted to a focus at the camera, and it is the peculiar property of this type of mounting that different parts of the same spectrum or different orders of spectra will all be brought to a sharp focus in the camera by simply sliding the tube with its carriages along the rails. Light from the sun may be reflected through the window from a heliostat placed on the balcony outside, while the spectra of the elements may be obtained by reflecting light from the arc or spark into the slit from a closed chamber near the spectroscope.

Other Laboratory Apparatus.

A good assortment of the apparatus most likely to be required in astronomical or astrophysical research is also available. It includes a Fuess heliostat; two projection lanterns with electric arc lamps and with lenses, prisms, mirrors and other accessories for optical experiments and demonstrations; an elbow polariscope and specimens for use with the lanterns; a Scheiner Toepfer sensitometer for testing photographic plates, and a Märtens polarisation photometer for measuring the densities of negatives; a Zeiss comparator with two micrometer microscopes, one reading on a silver scale and the other on the objects to be measured; a large standard resistance box and Wheatstone bridge for the measurement of electrical resistance; a sensitive aperiodic reflecting galvanometer with high and low resistance and ballistic coils; two standard cells for comparing electro motive forces; a Weston ammeter from 0 to 25 amperes, and a Weston voltmeter from 0 to 3 and from 0 to 150 volts; a Wimshurst influence machine and numerous smaller accessories and appliances including an outfit of laboratory supports and clamps.

Iced Bar Measuring Apparatus.

This apparatus made by Saegmuller of Washington and standardized by the United States Bureau of Standards has been received but is not yet in use, pending the construction of a suitable shed to contain it. It will be described in a future report when it has been installed and is in operation.

Seismograph.

This instrument by Bosch, of Strasburg, is arranged for photographic registration of earth movement, the principle being that of the oscillation of a horizontal pendulum. On two brass pillars attached to the base of the instrument, a small support is fixed so as to move forward and backward and obliquely up and down. The weight, a cylindrical metal piece, is bifilarly supported by two wires 18 cm. long which are attached to the before-mentioned support and incline out at an angle of about 20° to the vertical.

The horizontal thrust of the weight is taken by the arm of the pendulum 6 cm. long, whose point of support is nearly vertically beneath the point of suspension of the wires, and the sensitiveness can be increased or diminished by moving the point of suspension backward or forward.

The weight moves freely horizontally about the end of this arm, and directly over the point of support is fixed a concave mirror of 4 metres radius which can be adjusted about both vertical and horizontal axes, so as to send light reflected from it in any desired direction. In order to damp the oscillations of this sensitive pendulum produced by any disturbance, a light aluminum tube extends back from the weight opposite the supporting arm. This tube carries a thin aluminum vane which swings freely, but without much space, in a closed case. In consequence of the resistance of the air which this vane encounters as soon as any movement takes place, all oscillations are very soon lessened without any mechanical friction. This damping can be removed by simply taking away the glass cover of the case.

Two exactly similar instruments are installed one in the N.S. and the other in the E.W. direction, so as to obtain the two components of the disturbance, and the mirrors are so turned as to direct the light from an electric light towards the registering apparatus. This consists of a drum 90 cms. in circumference turned by clockwork once per hour and at the same time moved horizontally 4 cms. by a screw. The light from the two components makes uninterrupted traces on a piece of photographic paper wound on the drum so long as the pendulum is at rest, but any seismic disturbance causes the pendulum to oscillate, and these oscillations are at once recorded on the sheet. The clockwork runs and the sheet lasts for 24 hours, giving a continuous record of the two components during that time, and, since the velocity of the sheet is 90 cms. per hour or 1½ per minute, and the pendulum is very sensitive, the most rapid oscillations will be separated, and the faintest recorded.

Machine Tools.

The workshop, an essential part of an astronomical observatory, especially where astrophysical work is carried on, is fitted with a Hendey Norton 10-inch by 6-foot engine lathe, with all the necessary attachments including a 10-inch 4-jaw independent and a 6-inch 3-jaw universal chuck, and has a set of step-closer chucks fitted to it. It is arranged to cut threads in either English or metric pitch and is thoroughly equipped with small tools and accessories for all work within its range.

The Browne & Sharpe Universal Milling machine, No. 1½, will mill 20 inches long, 7½ wide and 18 inches high. Has index centres, with method of differential indexing that will divide any number to 389 and many beyond, so that gears may be cut or circles divided with the greatest facility. It is well stocked with arbors, milling cutters, and all necessary accessories.

The bench lathe, by the Faneuil Watch Tool Co., is of 8-inch swing, and is supplied with a 4-inch 3-jaw universal chuck, an Almond drill chuck, a set of step-closer chucks to ½-inch, and other accessories.

The shafting running at 200 revolutions per minute is driven from the motor by an intermediate countershaft at 600 revolutions per minute, is supported from the ceiling and belted to the countershafts of the machines. Owing to the low ceiling and limited space, the belts are too short for the best efficiency, but have ample power for the class of work likely to be done at the observatory.

A good birch workbench with drawers and two vices runs along the north wall of the room under the windows, and the shop is well fitted up with shelves for storage purposes.

Field Instruments.

Besides the observatory apparatus above described there is a fairly complete equipment of the field instruments required in the work of boundary surveys with others of a miscellaneous character. Their location in the instrument room, to whom and when lent, and when returned, with other details, are recorded in a card catalogue.

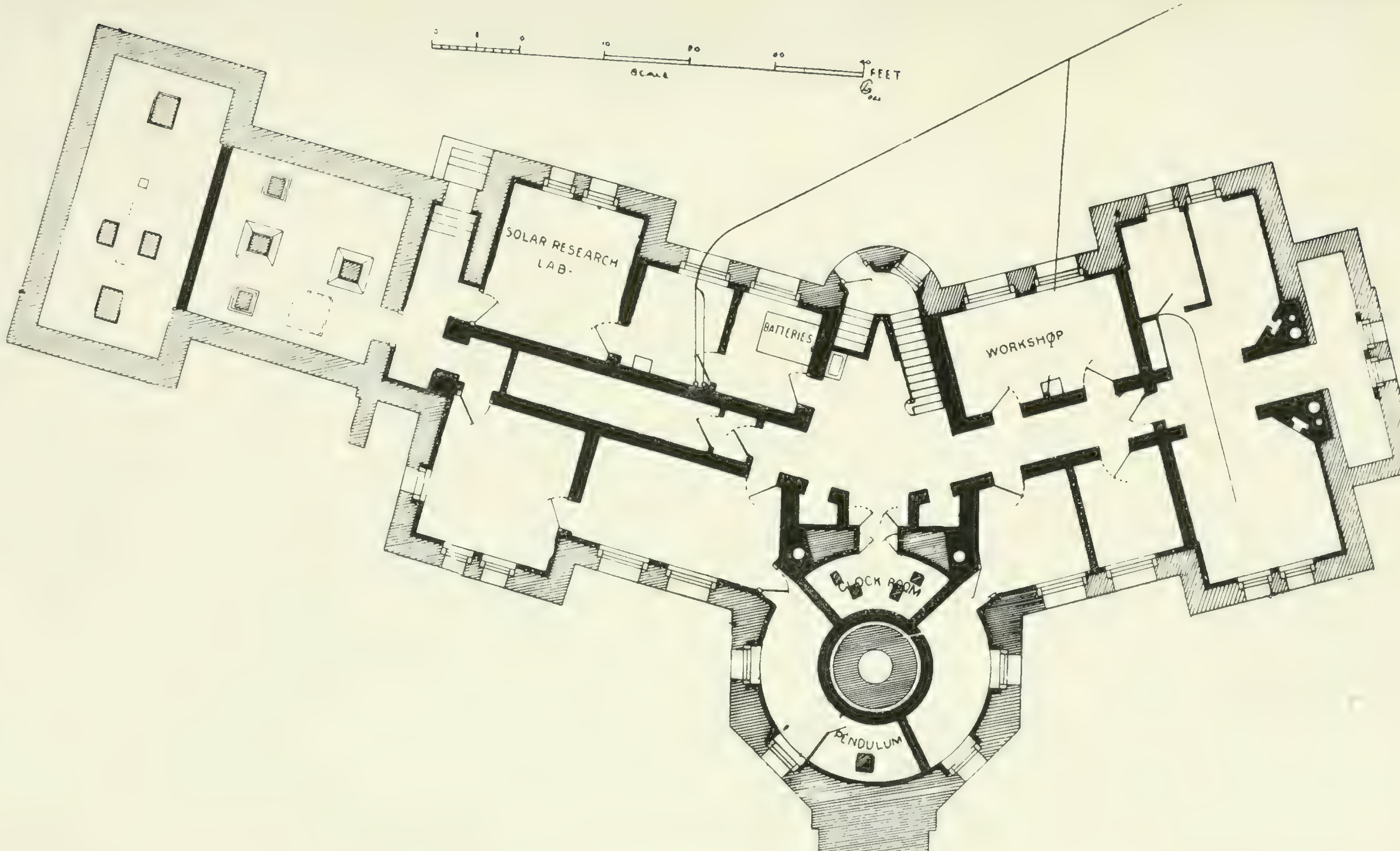


Fig. 1.- Basement of Observatory.

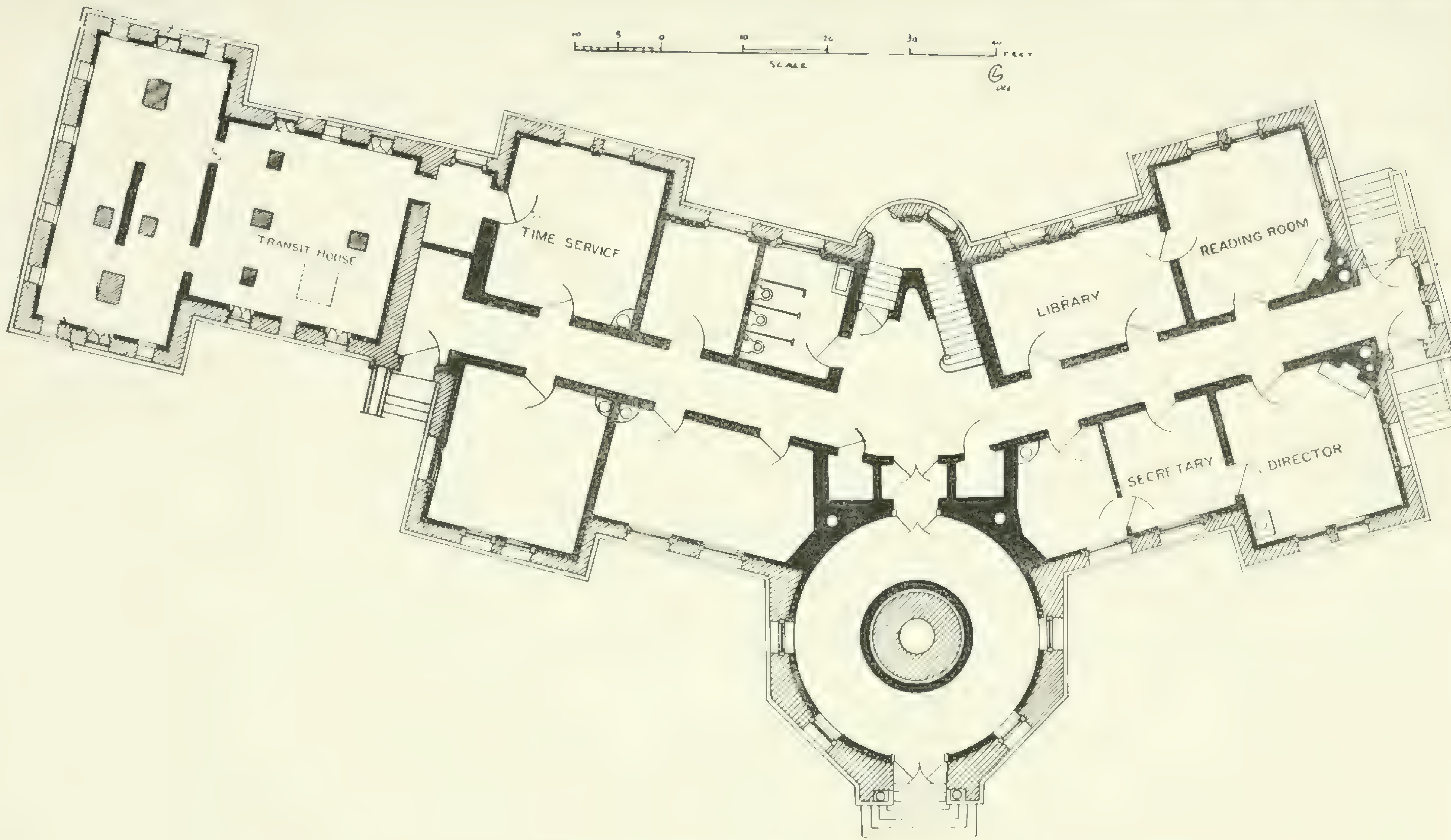


Fig. 2. Ground Floor of Observatory.

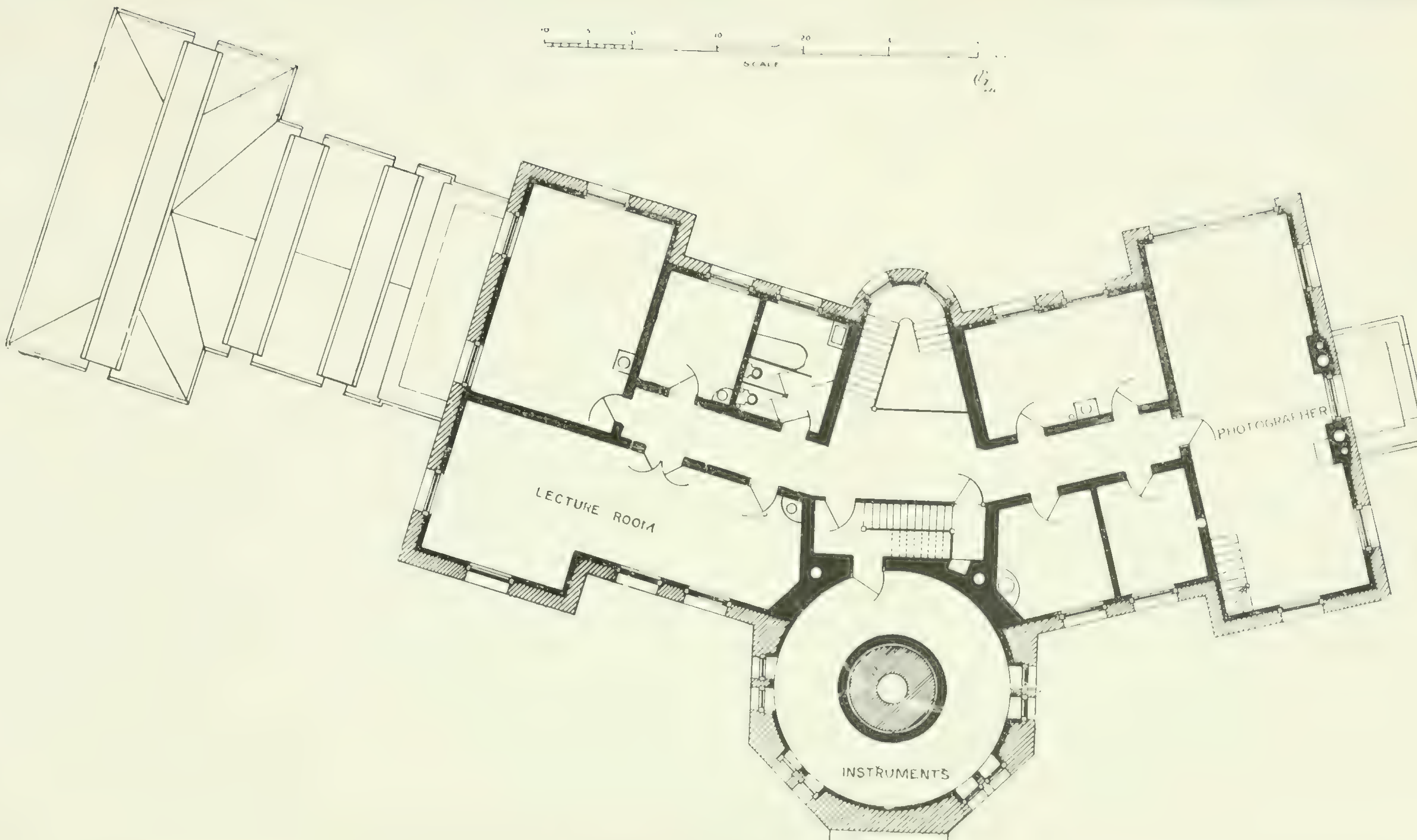
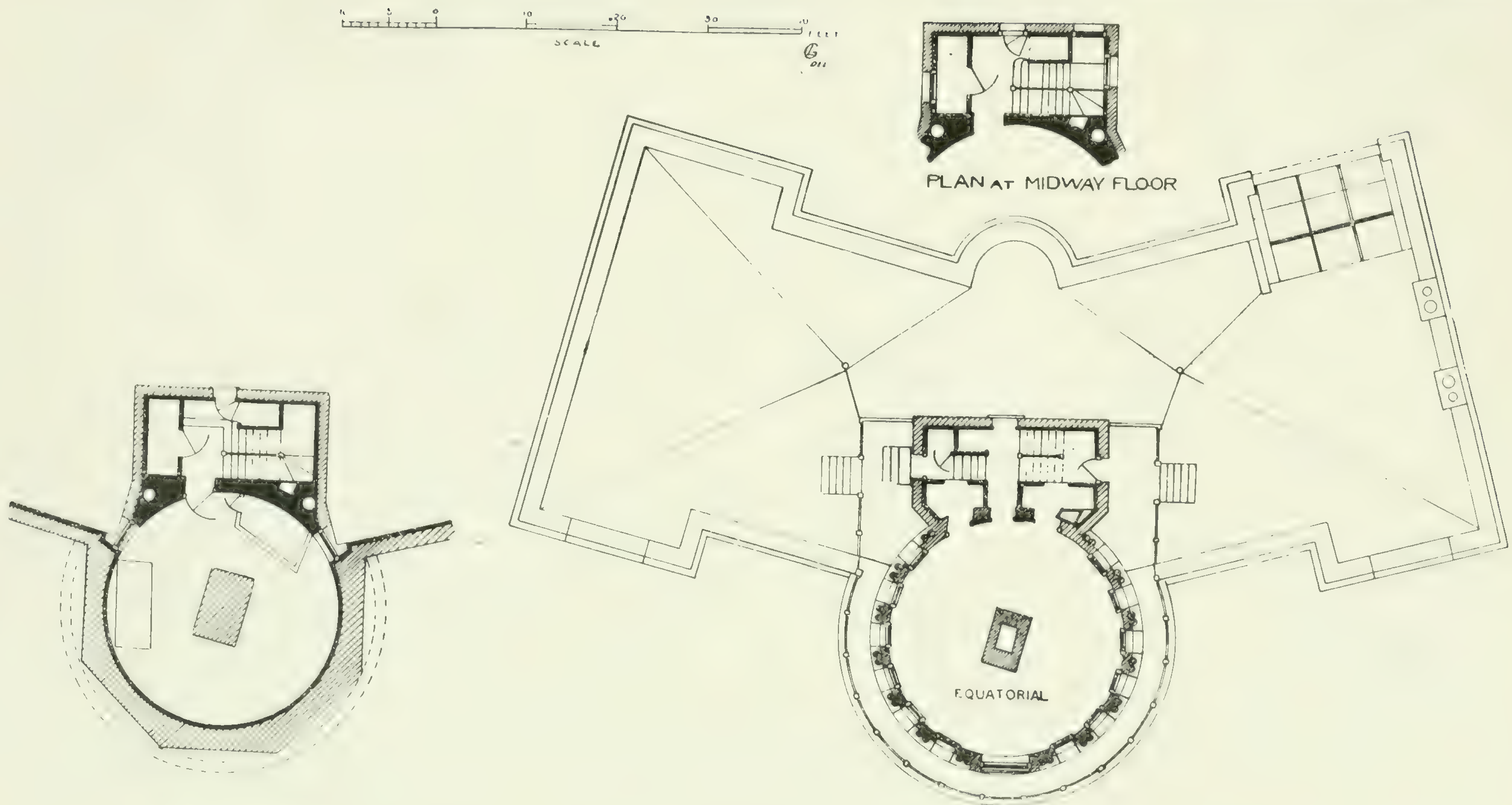


Fig. 3. First Floor of Observatory.



Midway Floor. Fig. 4. Roof of Observatory.

Fig. 5. Front of Observatory.

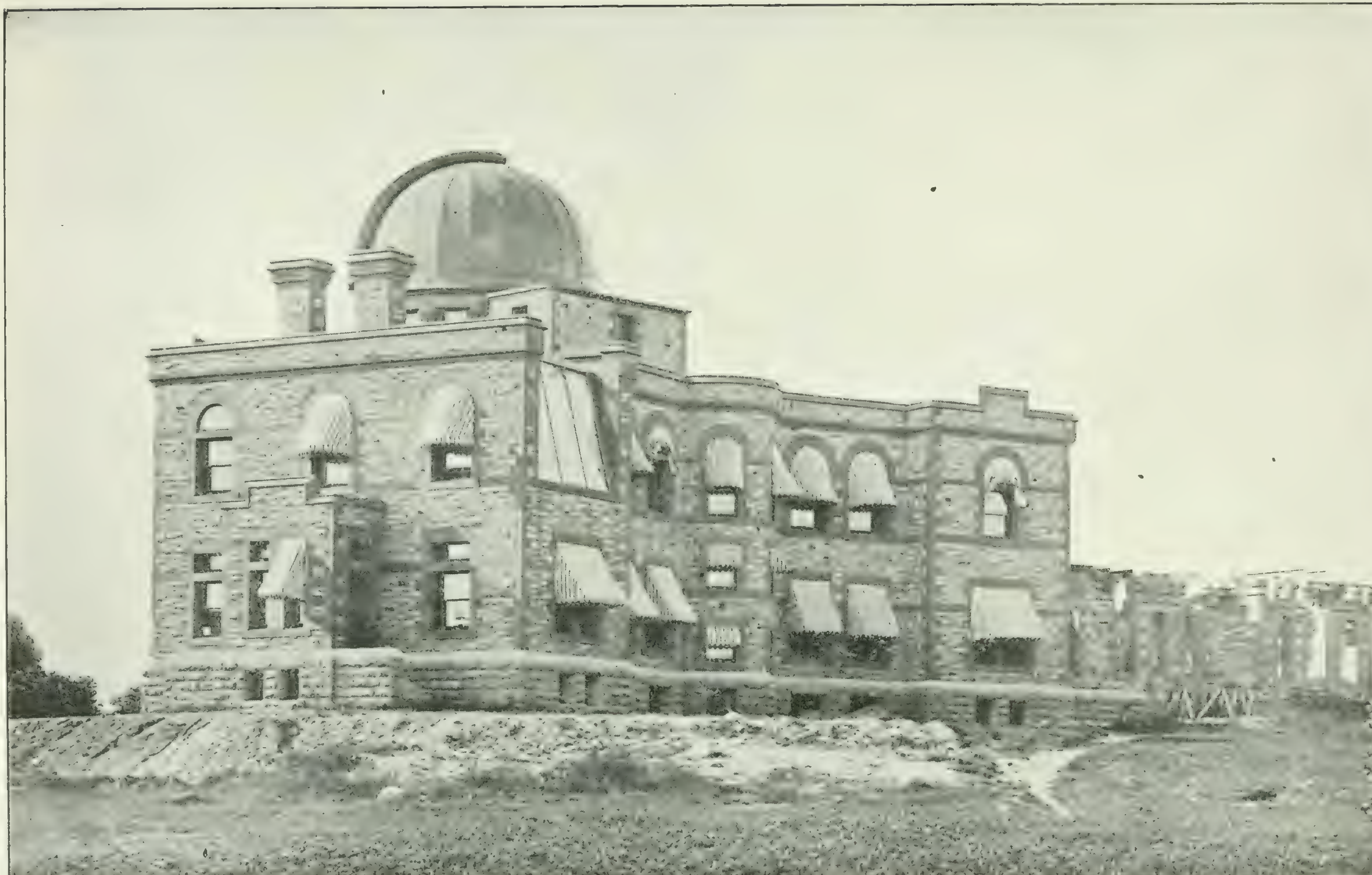


Fig. 6.—Rear of Observatory.

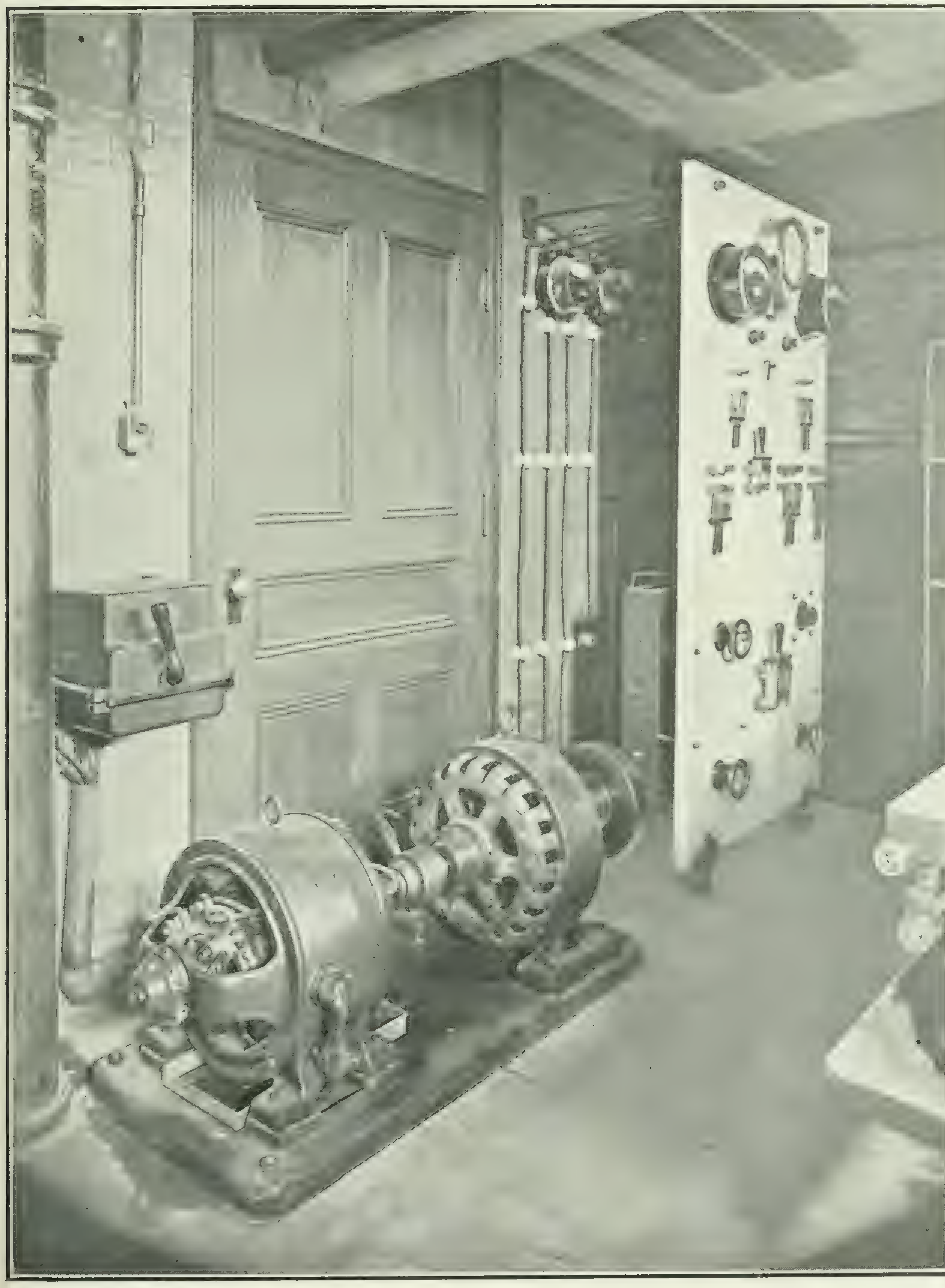


Fig. 7.—Switchboard and Motor-Generator.

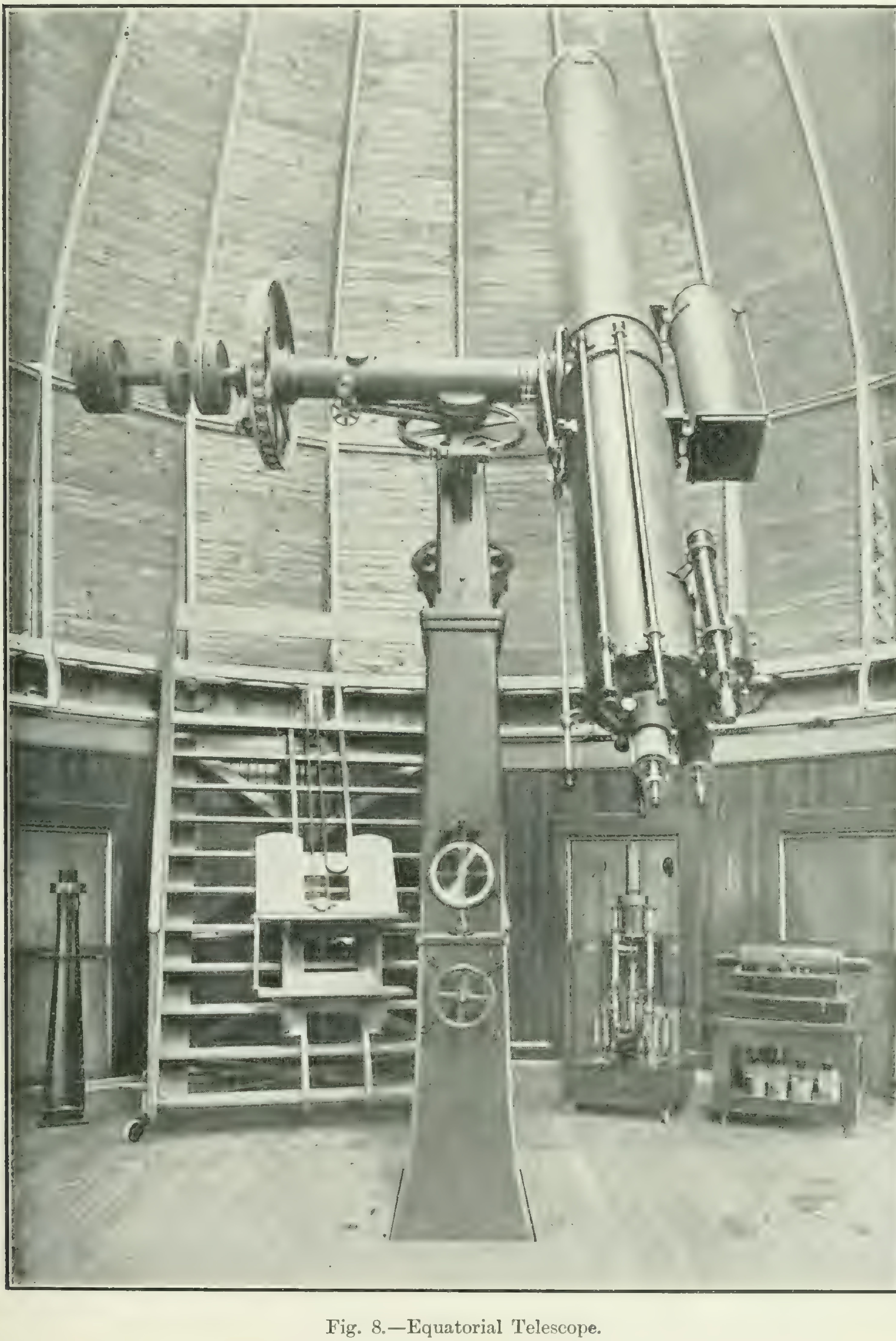


Fig. 8.—Equatorial Telescope.

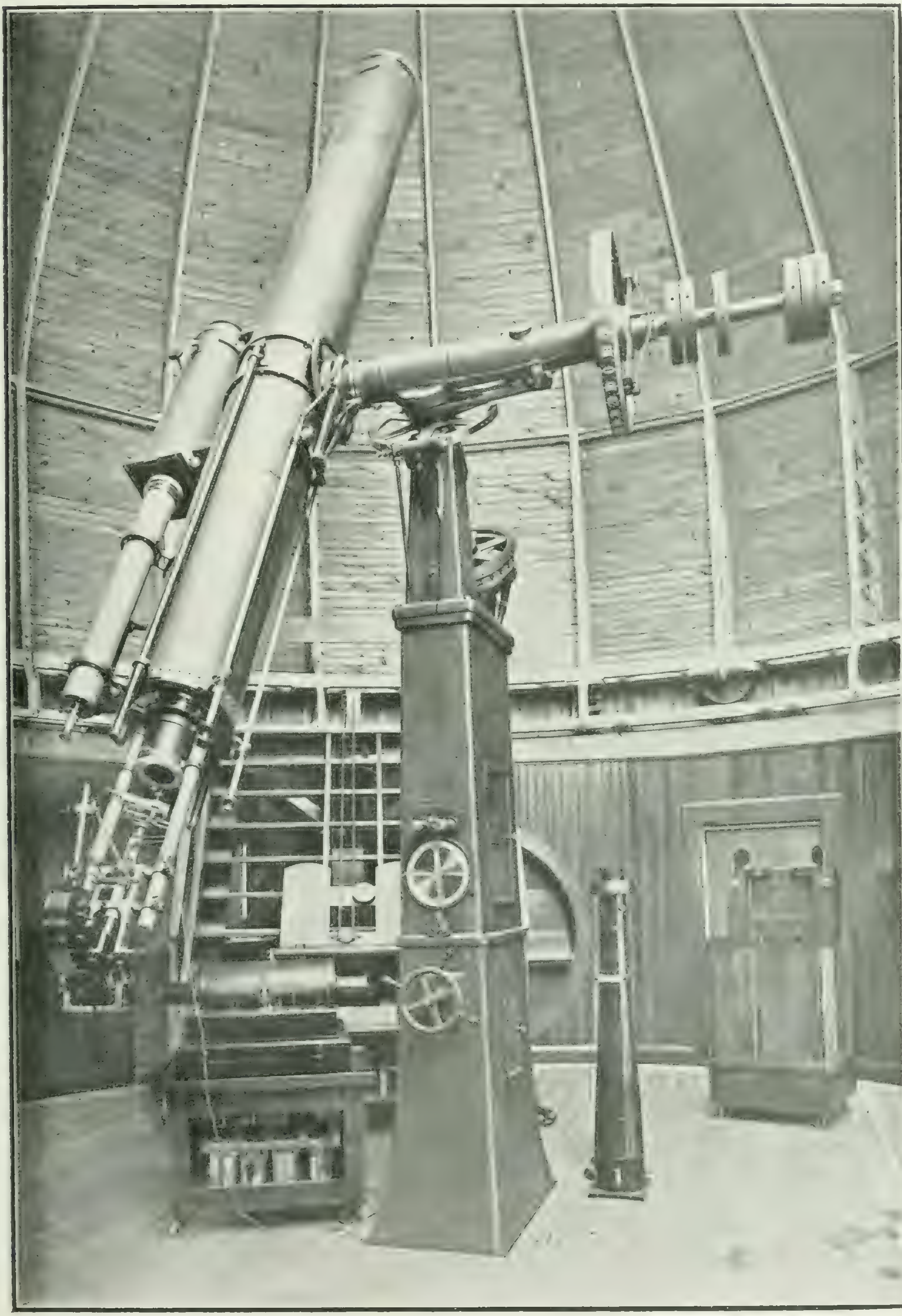


Fig. 9.—Equatorial Telescope with Spectroscope attached.

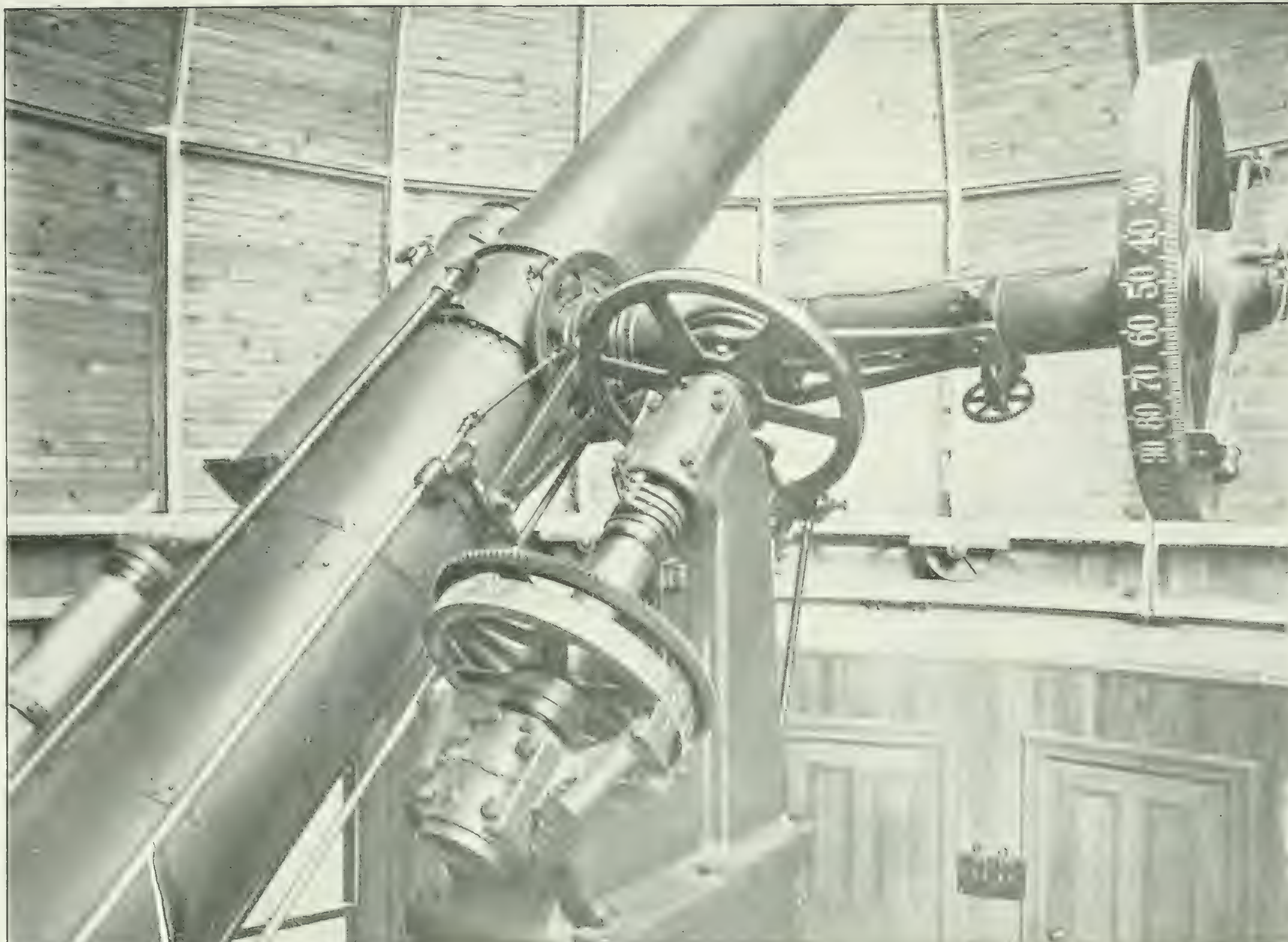


Fig. 10.—Polar Head of Equatorial Telescope.

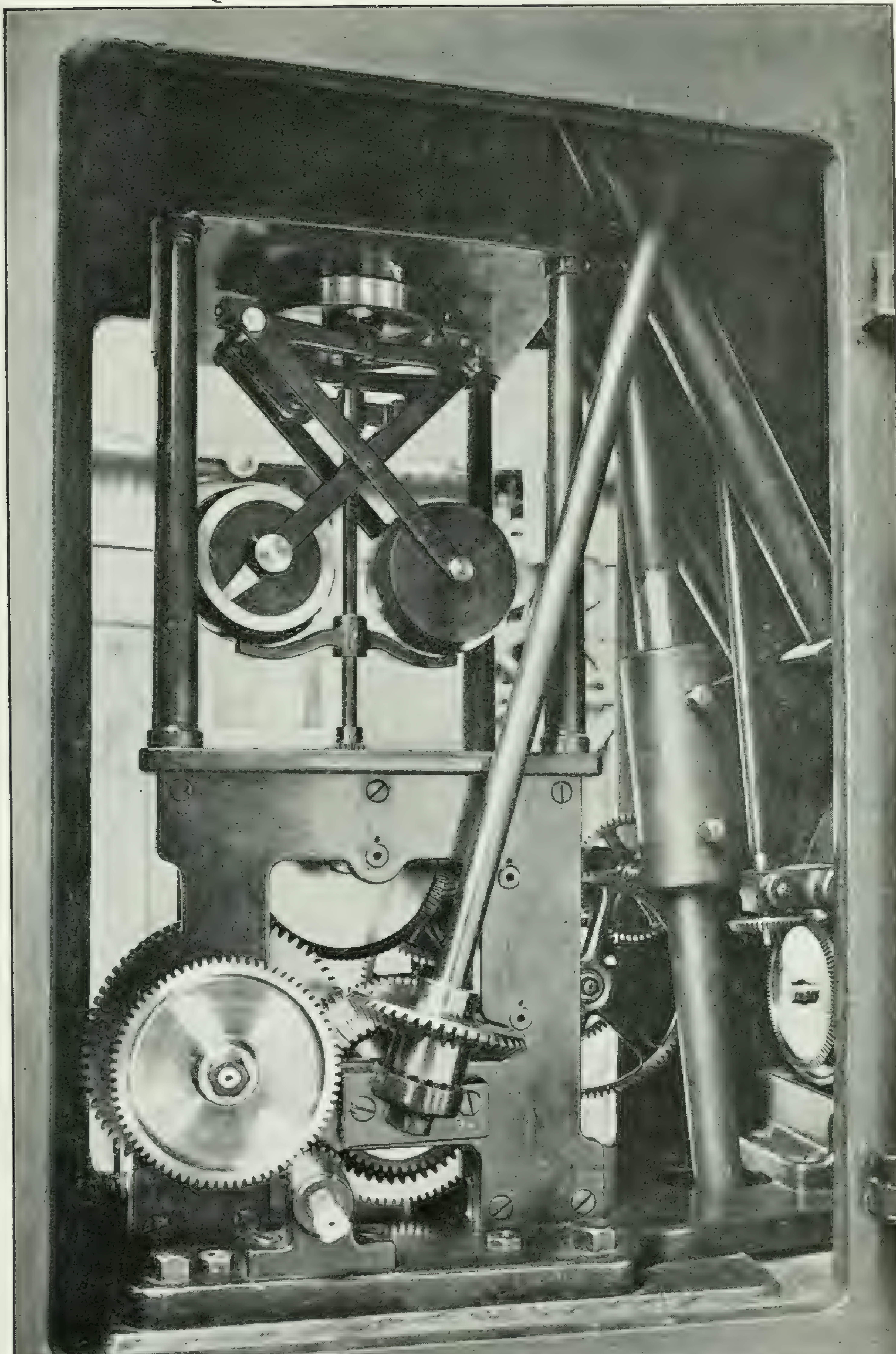


Fig. 11.—Driving Clock.

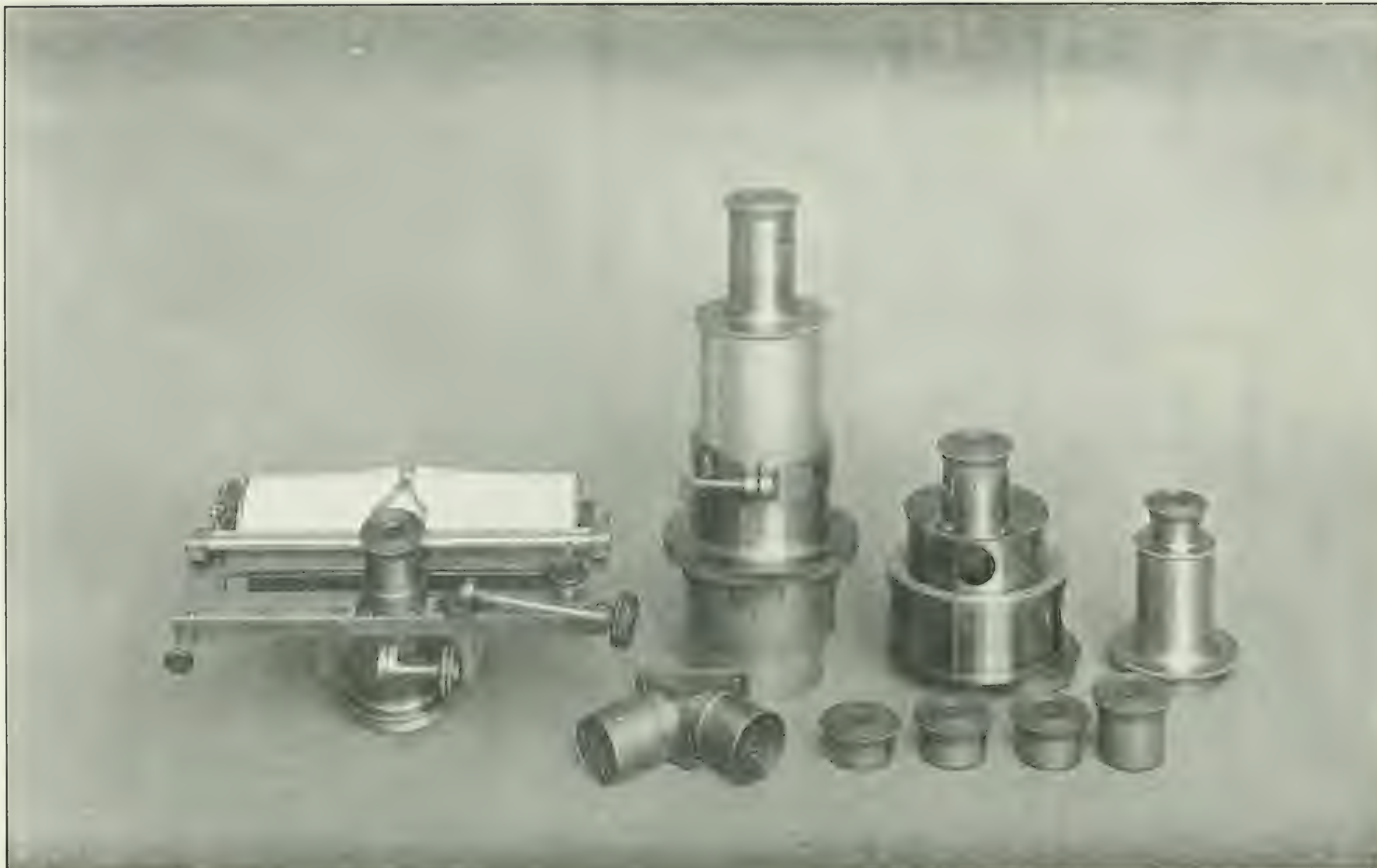


Fig. 12.—Registering Photometer and Telescope Eyepieces.

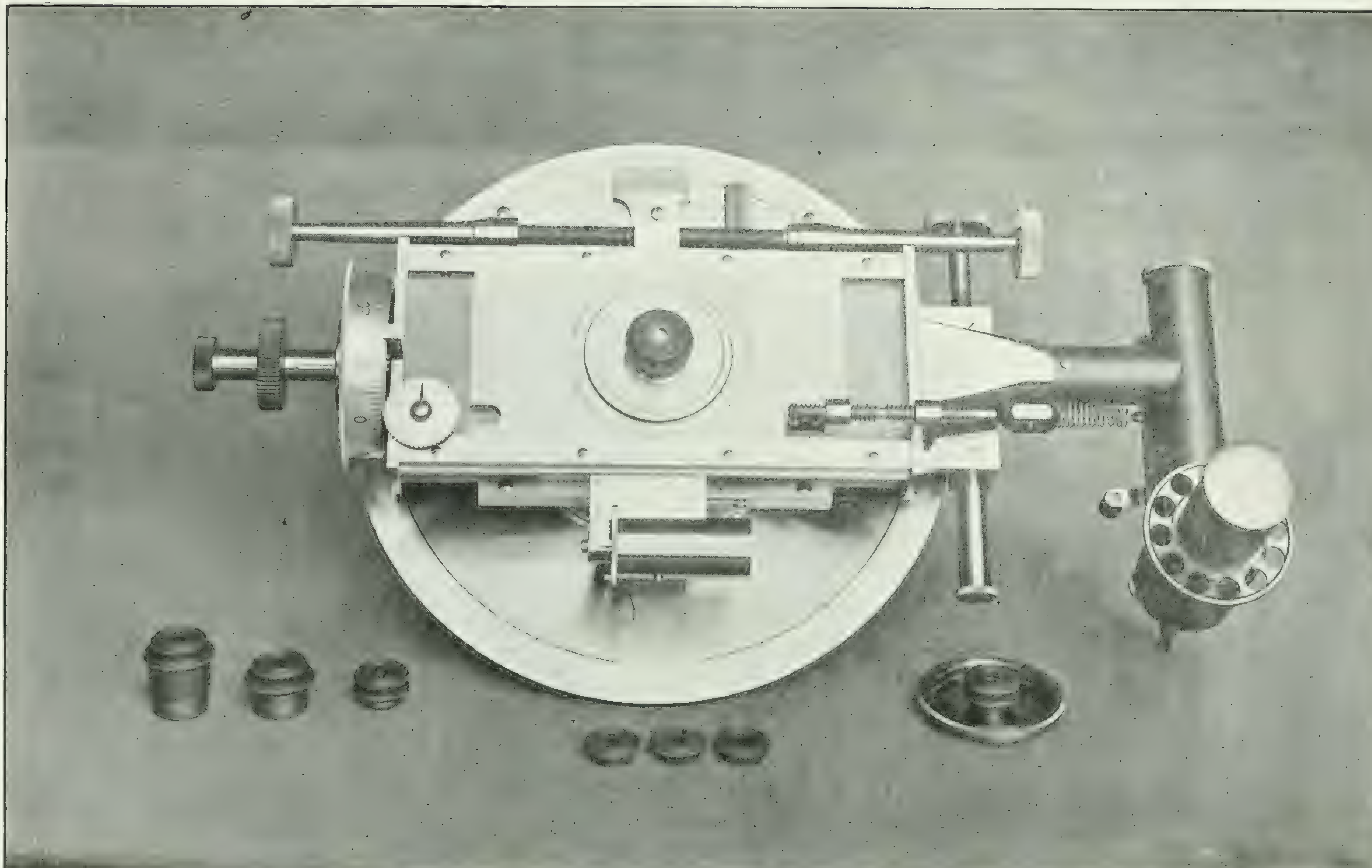


Fig. 13.—Position Micrometer with Accessories.

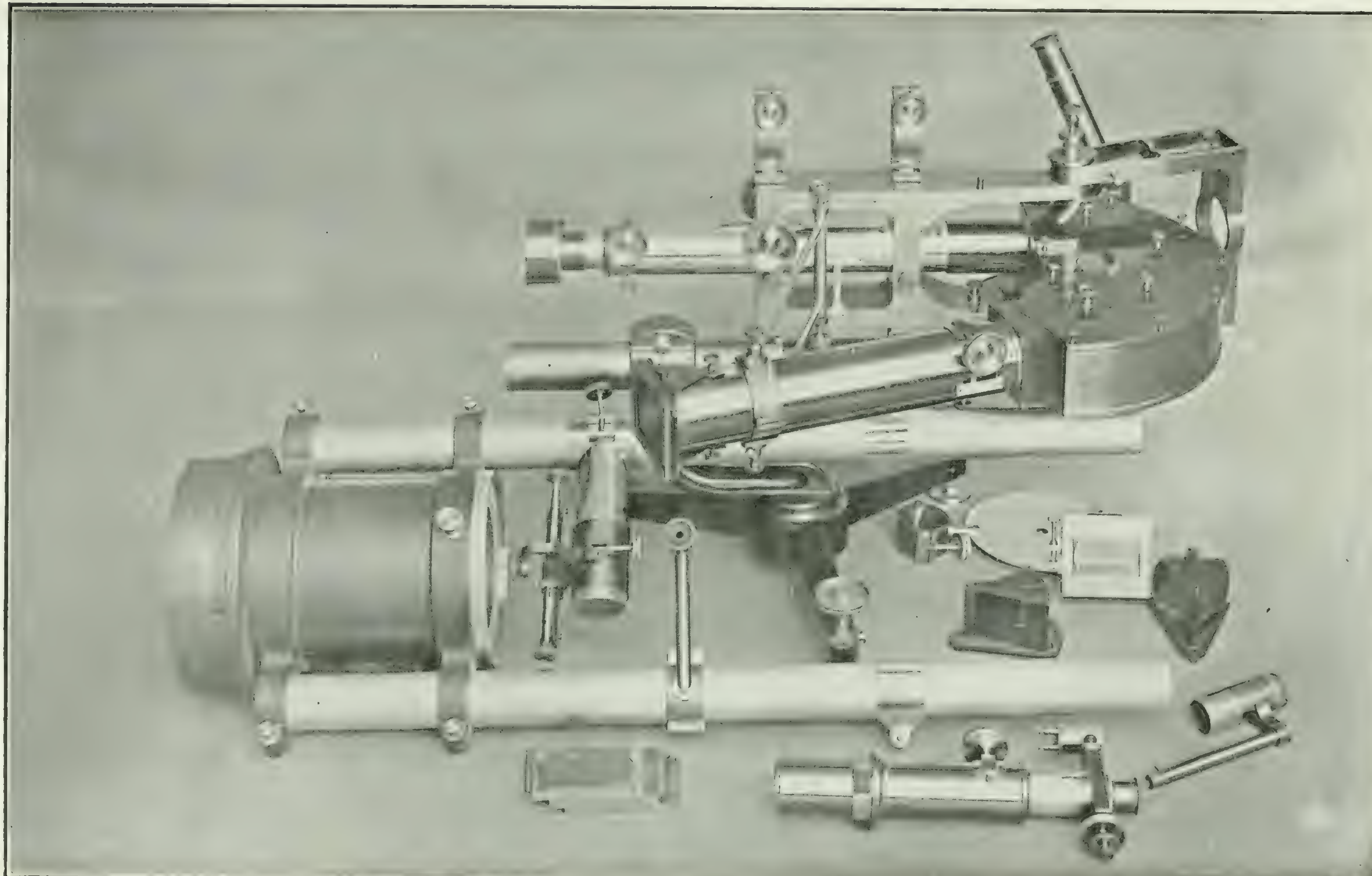


Fig. 14.—Spectroscope, Adapter, and Accessories.

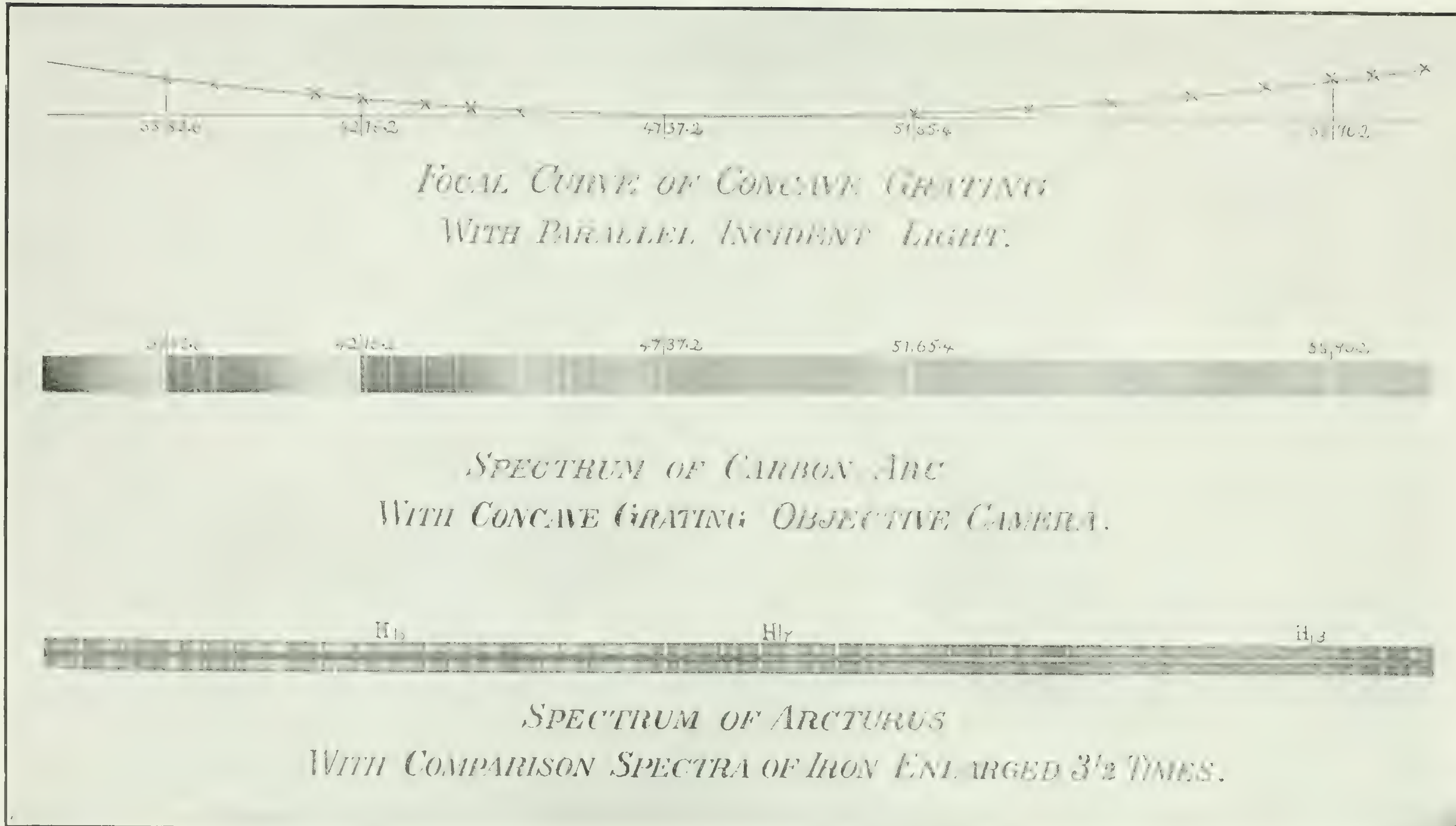

FOCAL CURVE OF CONCAVE GRATING
WITH PARALLEL INCIDENT LIGHT.
47|37·2
SPECTRUM OF CARBON ARC
WITH CONCAVE GRATING OBJECTIVE CAMERA.
SPECTRUM OF ARCTURUS
WITH COMPARISON SPECTRA OF IRON ENLARGED 3½ TIMES.

Fig. 15.

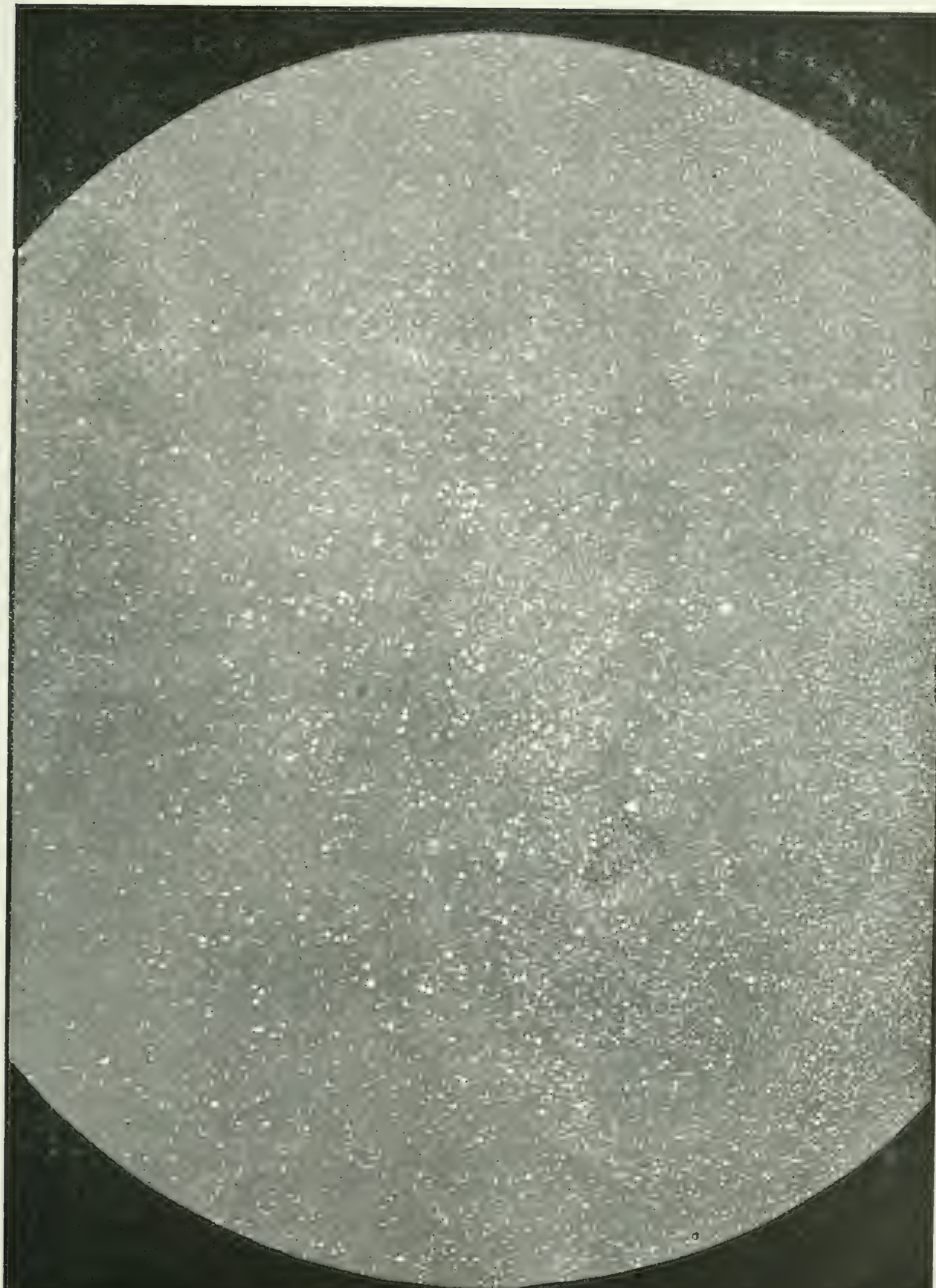


Fig. 16.—Photograph of part of Milky Way. Centre at R.A. 21h. 32m. Decln. +49° 5′.
Exposure 6hrs. 20min.

APPENDIX 5

REPORT OF THE CHIEF ASTRONOMER, 1905.

TOTAL SOLAR ECLIPSE, 1905

BY

J. S. PLASKETT, B.A.

CONTENTS

ILLUSTRATIONS.

APPENDIX 5.

W. F. King, Esq., B.A., LL.D., D.T.S.,
Chief Astronomer,
Department of the Interior,
Ottawa.

Ottawa, Can., October 31, 1905.

Sir,—I have the honour to report as follows upon the observations planned for the total solar eclipse of August 30, 1905.

I have the honour to be, sir,
Your obedient servant,

J. S. PLASKETT.

REPORT ON SOLAR ECLIPSE EXPEDITION.

When I was entrusted by you with the observations to be undertaken by us, obviously the first thing to be done was to look over the work already accomplished at former eclipses and to find out what it was proposed to attempt at the present one, and then to choose some line of work which would not uselessly duplicate something already done or about to be done.

The short duration of totality in all solar eclipses, this one lasting, at the chosen station two minutes and thirty-one seconds, must necessarily confine observations of the physical phenomena connected with the eclipse, and especially those dealing with the constitution and appearance of the atmosphere surrounding the sun, to photographic records. By properly devising and arranging the apparatus a number of these may be made during totality which will be available for measurement and discussion at leisure. Visual observations and sketches of the corona and prominences, although useful in their way, can only be of a general character, and the most skilful draughtsman cannot hope to produce in his sketch one-quarter of the detail truthfully rendered by a photograph in less than one hundredth of the time. Similarly in regard to the spectra of the reversing layer and corona. The time during which the former is visible is probably not more than two or three seconds and the eye cannot do more than recognize the general character of the spectrum while there would not be time to measure the position of even one line. A photograph, on the other hand, may faithfully record the positions of a thousand lines, each of which may be much more accurately measured than one line visually.

Hence it was thought preferable to confine the observations undertaken by us entirely to photographs of the corona and prominences and to photographs of the spectra of the corona and reversing layer and to leave the visual and other observations to the amateur members of the party who would not be so well equipped for photographic work as ourselves.

PHOTOGRAPHS OF THE CORONA.

On looking over the work already accomplished in coronal photography and in ascertaining what was proposed for this eclipse, it seemed that, as far as regards photographs on ordinary plates, that is plates sensitive to light of the shorter wave lengths from λ 5000 down, the whole field was fairly well covered. When, however, it came to results obtained or even attempted on plates sensitive to the longer wave lengths, to

green, yellow and red as well as blue and violet, it was quite a different story. Only very few, and, so far as I can learn, no carefully prepared attempts have been made to photograph the corona on other than the ordinary plates, that is to say by constituents of the coronal light other than the blue and violet. An analysis of the corona by the spectroscope shows, so far at any rate as the gaseous part, giving a bright line spectrum, is concerned, that the blue and violet is by no means the most important part, but that by far the brightest and most characteristic line is in the green about wave length λ 5303, a region to which ordinary plates are very, and the usual orthochromatic plates comparatively, insensitive.

Hence it seemed worth while, in view of the comparatively unoccupied field, and also on account of the previous training of the writer in orthochromatic and three-colour work, to make a carefully prepared attempt to obtain photographs of the corona by light of this wave length. Such photographs should show the distribution of the so-called coronium gas around the sun's disc and, by comparing them with ordinary photographs of the corona of the same relative exposure, allowing for the absorption of the filter or screen used, we should be able to clearly separate the part due to this hypothetical gas from that due to incandescent particles and to reflected sunlight, and thus to considerably increase our knowledge of the constitution and relative distribution of the coronal matter. Similarly photographs of the corona by red and by yellow light should also, when compared with those obtained by green light, and by blue light, show some interesting and instructive differences of structure as well as give us some idea of the relative intensities of those colours in the coronal light. Further, by properly choosing the absorptions of the screens or filters used for obtaining these monochromatic renderings, it should be quite possible to obtain a successful photograph of the corona in the natural colours by combining the photographs of the corona by red, green and blue light in the same way as in the regular three-colour process. The negatives then would serve two purposes, one to obtain the relative intensities and distribution of these colours in the corona and the other to obtain a record of the corona in its natural colours.

The objective to be used for obtaining these monochromatic and three-colour records should be one of fairly large angular aperture, since, owing to the absorptions of the screens employed, the exposures required would be considerably increased. Moreover a lens specially corrected for the red and green for which it was proposed to use this objective, would be required, so that the focus for these two colours would be the same. A 4½-inch Cooke-Taylor photo visual objective, which we already possessed, fulfilled these conditions fairly well and was accordingly chosen for this work. Its focal length of 81·8 inches gives a solar image about ¾-inch diameter and makes the aperture ratio f18.

For the yellow and blue records there were no suitable objectives available and considerations of economy, future usefulness, size of solar image, and mirror surface required, dictated the size ordered, 4-inch aperture and 10 feet focus. Further it was deemed desirable to obtain some photographs of the corona on a fairly large scale and an objective of 5-inch aperture and 45 feet focus was added to the other two.

The programme of photographs of the corona as finally arranged for was as follows:—

1. A series of photographs of varying exposure on ordinary plates for the details of the inner corona by an objective corrected for the photographic rays, of 5 inches aperture and 45 feet focus, thus giving the image of the sun a diameter of about 5 inches.

II. A series of photographs of inner and outer corona by two objectives of 4 inches aperture and 10 feet focus giving images of the sun nearly 1⅛ inches diameter. One of these objectives corrected for photographic rays to be used with ordinary plates giving photographs by blue and violet light only; the other corrected for the yellow and yellow green light and used in conjunction with a yellow screen or orthochromatic plates to obtain photographs by yellow light only.

III. Photographs of the corona by red and green light through screens of a suitable absorption for three-colour work. Also photographs of the corona by the monochromatic coronium light of wave length λ5303 through a screen constructed so as to absorb as nearly as possible all light but that of this particular wave length. These photographs to be taken by the 4½-inch Cooke photo visual 81·8 inches focus on plates specially sensitized for the purpose.

PHOTOGRAPHS OF THE SPECTRA OF REVERSING LAYER AND CORONA.

The reversing layer, the thin shell of incandescent gases surrounding the photosphere, whose absorption produces the dark lines of the solar spectrum was first discovered by Prof. Young in 1870, but was not successfully photographed until Shackleton in Nova Zembla in 1896 succeeded in recording it upon one of his plates. Since then many photographs of this evanescent phenomenon have been obtained, but there still remains a great deal to be learned of the nature of this shell, of the gases of which it is composed, of their distribution throughout the shell, and finally of the relation between its spectrum and the corresponding dark line solar spectrum. It was hence determined to get as many photographs of its spectrum as possible. The spectrum of the corona has also been frequently photographed but the wave lengths of its bright lines are still subject to considerable uncertainty. It is desirable that they be accurately measured in order to definitely ascertain whether coronium can be identified with any known substance and further to learn whether any series relation between the lines can be discovered. It was therefore determined to obtain photographs of the corona spectrum with special reference to the wave lengths of its bright lines. For photographing the 'flash' spectrum the most suitable apparatus is a prismatic camera or an objective grating camera, while for the accurate determination of the wave lengths of the corona spectrum a slit spectroscope with a train of prisms, such as is used in radial velocity work, would give the best results. Hence the programme already given would be added to as follows, especially as the optical parts of the apparatus were already in our possession.

IV. Photographs of the spectra of the reversing layer and of the corona by a prismatic camera and also by a concave diffraction grating camera.

V. Photographs of the spectrum of the corona with special regard to accurate measurements of wave lengths by a slit spectroscope with a train of three prisms.

INSTRUMENTAL EQUIPMENT.

The programme of observations decided upon, it was deemed advisable before designing the cameras and spectroscopes to settle upon the most efficient and economical means of overcoming the diurnal motion. That such a compensation is necessary will be evident when we consider that the sun's image in any stationary camera will move the distance of its diameter every two minutes. Of the two usual methods of compensation, first, that of mounting the cameras on polar axes and driving by clock work, or second, that of reflecting the light into stationary cameras by a plane mirror moved by clock work, it was early decided that the latter would be by far the more satisfactory. The principal reasons for this decision were, the almost absolute rigidity of the camera installation by the latter method as compared with its unstable and shaky position by the former, and also the much more convenient position of the cameras, for the necessarily rapid changes of plate holders, when installed horizontally, as is easily arranged when fed by a moving mirror.

USES OF COELOSTAT OR SIDEROSTAT.

The one drawback to this method lies in the greater initial cost of the siderostat or coelostat, as such a moving mirror is called, over the equatorial mounting of the

cameras. But such a consideration only properly applies when the conditions as regards usefulness for other than eclipse purposes are equal. If, however, as I shall presently show, the siderostat or coelostat may be kept in constant and useful service at the observatory while the equatorial mountings would be of little service for anything but eclipse work such an objection will have little weight and there need be no hesitation in deciding upon obtaining such an instrument.

The most important use to which such a moving mirror may be put is to form a stationary horizontal reflecting telescope of long focus which may be used to great advantage for research work upon the sun or other celestial objects. Its advantages over the ordinary equatorial telescope are numerous. The image and the axis of the cone of light are both stationary, the solar image may be of any size desired depending upon the focal length of the concave mirror, and it may be formed within a laboratory which if desired may be kept at constant temperature. Moreover the modern spectroscopes and spectroheliographs, which are too heavy and cumbersome to be successfully attached to any equatorial, may be rigidly mounted in a fixed position on piers for use with such a telescope.

The special application of such an instrumental equipment is to be found in work upon the sun. One of the most important scientific problems of the day is to determine the relation between the cyclical changes in the conditions of the sun and the meteorological and climatic conditions upon the earth. But the first step towards the discovery of this relation, which is doubtless of a very complex character, must be to understand as thoroughly as possible the constitution of the sun. This is the primary object for the formation of eclipse expeditions, and it justifies the expenditure of time and money for that purpose. But it will not suffice to confine attempts at solving this problem to the few short moments of totality. A combined and continued attack with all the forces at command is necessary, and that this is beginning to be recognized is shown by the grant of $150,000 for this year from the Carnegie Institution to a solar research observatory on Mount Wilson, California. The principal instrument in this observatory is a coelostat reflecting telescope, and the installation of such a telescope, of which the most important part is the coelostat or siderostat, and the work in which it may be used, which promises, above all other astronomical work, the most direct benefit to mankind, seem to be eminently suited to a national observatory.

These considerations, with the decided advantages of the coelostat or siderostat over the equatorially mounted cameras for eclipse work were deemed more than sufficient to compensate for its greater initial cost, and, when the matter was laid before you in this way, you decided upon purchasing such an instrument.

PRINCIPLES OF SIDEROSTAT AND COELOSTAT.

There are two general types of clockwork driven mirrors, the siderostat or heliostat, and the coelostat. In order to render the choice of the latter type intelligible, it seems preferable to explain, as briefly as possible, the principles of their action and the mechanism producing their motion.

The siderostat or heliostat, according as the clock is rated and the instrument used for the stars or sun, consists, essentially, of a plane mirror pivoted to move freely around both vertical and horizontal axes so that a rod rigidly attached normally to the back of this mirror can be made to point or move freely in any desired direction. This direction is governed by the rotation, once in 24 hours, of an axis, parallel to the axis of the earth, to the end of which is attached a rod making an angle with the polar axis corresponding to the polar distance of the celestial object. At the outer extremity of this rod a universal joint carries a collar which slides freely, yet without play, over the normal rod before-mentioned. When a simple geometrical relation between the arms of this lever system is fulfilled, the light from the celestial body is reflected in a fixed direction which may, within limits, be varied at pleasure. Theoretically the arrangement leaves nothing to be desired, but, from a mechanical standpoint, the nicety of workmanship required in the sliding collar and universal joints is so delicate, that, so

far as I can learn, a smooth and even running siderostat has not yet been made. The tendency seems rather to go by jerks which, although minute, are fatal to fine definition in long exposure photographs. The siderostat possesses the further drawback of rotation of field, one point only being fixed while the rest of the field has a slow motion of rotation around this point.

The coelostat both optically and mechanically is a much simpler instrument than the siderostat. It consists of an axis, parallel to the earth's axis, having a motion of rotation once in 48 hours, and carrying a mirror with its plane in or parallel to this polar axis. Evidently the direction of the reflected light depends on the declination of the celestial body, and the instrument has the disadvantage of requiring different positions of the observing telescope for different objects, or for objects whose declination varies such as the sun. In all other respects, mechanical simplicity, no sliding collars, or universal joints, no rotation of field, the coelostat is superior to the siderostat.

The change of direction of the reflected light with the change of declination does not give rise to any difficulty in eclipse work, as the apparatus may be set to suit the declination of the sun at the eclipse. The rate of change of declination is so small as to be imperceptible in the position of the image for a much longer period than the duration of totality. By the addition of a second adjustable mirror, this drawback may be overcome and the instrument may be adapted for observatory purposes with a stationary telescope. When, in addition, the cost of the coelostat is considerably less than that of the siderostat, the question practically decided itself in favour of the former. The question of size of mirror required now comes up for consideration. Not only must the apertures of the objectives be taken into account, but also, as far as the cameras are concerned, the size of plate. Since the axes of all the instruments fed by the mirror must be parallel, the centres of the objectives cannot be placed nearer one another than the centres of their corresponding plates. It was decided, from considerations of the probable extensions of the corona, to use 4¾-inch by 6½-inch plates for the photo-visual 6½-inch by 8½-inch for each of the two 10 feet focus lenses while the objective end of the 45 feet focus would require a space about 8 inches square, the grating camera about 5 inches square and the prismatic about 3 inches square. A drawing of the best possible arrangement of these instruments, and as they were finally placed, is seen in fig. 5. Allowing a little margin for the extension of the field due to the distance between mirror and objectives, and for the diminution of effective aperture, due to the inclination of the plane of the mirror at the time of eclipse, it is seen that 20 inches diameter is the minimum size that will completely fill the objectives. Since this size when used with a secondary plane mirror of the same diameter will completely fill a 15-inch concave even under unfavourable conditions, and will, during the greater part of the time it is likely to be used, nearly fill an 18-inch concave, it was decided to obtain a coelostat with a 20-inch mirror.

It is unnecessary here to go into the motives that governed the general design of the coelostat, as the instrument has proved very suitable for the work required of it, and as the details appear in the description of the instrument. One essential point, however, was that no part should much exceed two hundred pounds in weight owing to difficulty of transport in a rough country. This stipulation was adhered to except in the case of the lower section of the column, which weighed about 350 pounds, but was not essential to the working of the instrument, and could be left at home if desired.

DESCRIPTION OF COELOSTAT.

The photograph, fig. 2, exhibits fairly well the general design of the instrument. The mirror, not shown in the photograph, is about 20½ inches diameter and 3½ inches thick, silvered on both front and back surfaces. It rests in a circular cast-iron cell provided, as shown, with Ritchey's system of counterpoises for preventing flexure. This cell has at each end of a diameter two steel shafts, firmly attached to the cell and ex-

tending out some distance beyond the bearings to carry the driving sector at the north end, and with room at both north and south ends for a 10-inch or 12-inch mirror. A cell to carry an 8½-inch concave mirror, which we already possessed, was provided and furnished with clamps and slow motions in right ascension and declination: this cell being shown on the south end of the polar axis.

The bronze bushings, in which the axis and cell turn, are set in receptacles with screw caps at each end of a heavy cast semi-circular sector provided with a graduated arc, and a worm screw gearing into a circular rack fastened to the sector. By turning the worm, the sector rotates in its bearing on the upper part of the column, and the axis can be set at any altitude from 0° to 60°. Thus the instrument can be used at any place between the equator and 60° north or south latitude. Set screws are provided to rigidly clamp it in position when once set.

Below this polar head is the middle section of the column which also acts as clock case and is provided with a glass door at each side for convenience of access to the clock mechanism. The clock is of the ordinary type of conical pendulum, the rate being varied by lengthening or shortening the pendulum arms, this being effected by screwing the balls up or down, a lock nut serving to firmly fix them in the desired position. The braking is done by a knife edge on the pendulum arms engaging, when the balls rise, with arms attached to a friction disc rotating concentrically with the spindle. The motion is communicated through the clock train by bevel gears to a short shaft which again gears into a shaft containing a differential gear mechanism which serves to give a slow motion to the mirror. It is actuated by a cord passing around a grooved wheel, which can be led, through holes in the end of the column, in any desired direction, and to any required distance. From this shaft bevel gears transmit the motion to a connecting rod passing up through the column to the driving worm and sector. Two sets of gears on the end of the connecting rod and worm, either of which can be engaged as desired, give the mirror a motion of rotation of once in either 48 or 24 hours. With the former the instrument acts as a coelostat, and with the latter rate, and a plane mirror on either end of the polar axis, it could be used as a polar heliostat. The driving sector has an arc of 45°, and is hence long enough with the coelostat motion to drive for six hours without turning back.

The lower or base section of the column tapers by graceful curves from 34 inches by 36 inches at the bottom to 20 inches square at the top. It is provided with screws for adjustment in azimuth, and with removable doors at each side to give access to the clock weights. The height of the instrument to the centre of the mirror is 58 inches, and it is thus fairly compact.

The arrangement of the details is very convenient and serviceable, while the workmanship and finish are excellent. Of the mirror, Dr. Brashear says it is probably the best they have made, the radius of curvature being not less than 500 miles. We may rest assured that it cannot be excelled anywhere, and that the instrument should give excellent results in solar work.

THE CAMERAS (GENERAL).

The camera boxes, whose general construction may be readily obtained from the illustrations (figs. 5, 8, 10), were designed to be as compact as possible, practically the same external dimensions as the plate holders, in order to economize mirror surface and were made with parallel sides without projections for the same purpose and for convenience in mounting. The bodies were made of whitewood, panelled in the larger sizes to prevent warping, with backs of birch or cherry, while the objectives were mounted in short boxes made to telescope into the cameras for adjustment to focus. Each of the boxes was lined throughout the interior with black velvet to prevent reflections, as, owing to the small size of box and large size of objectives, it was impracticable to place diaphragms in them.

Instead of arranging the plate holders to slide in and out of grooves in the camera backs, which occupies too much time in the changing or reversing of holders, par-

ticularly with the large sizes, the backs were made with a groove at the bottom as wide as the holder was thick and a spring catch at the top, so that, to insert a plate holder, it could be simply dropped into the groove and then shoved forward, forcing up the catch at the top until it came to its seat, when the catch would drop, holding it in place; while to remove the holder all that was necessary was to pull it back with one hand while the catch was lifted with the other. Care was taken to have a thorough light-break all around the holder, so that there would be no danger of fog. It was found that this arrangement worked admirably, saving considerable time in changing holders.

The exposing devices were simple flap shutters of aluminum, blackened all over, and working on a simple hinge. A cord attached to a lever fastened to the shutter was led back through screw eyes to the operator, who thus exposed with one hand the instant he had drawn the slide with the other. This scheme insured saving of time, prevented crowding and confusion, lessened chances of spoiled plates, and besides only required half the assistance necessary for exposures made by a second person. In the long focus and Cooke cameras, in which the shutter was light, a small rubber band attached to the shutter and stretched over a screw at the side of the camera box insured the quick closing of the shutter besides forcing the metal shutter to strike against the cell of the objective, making an audible click which served to tell the operator without looking that the shutter was working properly. This was especially necessary in the case of the 45 foot camera, as the operator could not see the shutter.

The 45-foot Camera.

The objective as before stated was of 5 inches aperture and nearly, as appeared later, 45 feet 4 inches focus. It was made by Grubb, of Dublin, and was corrected for the blue and violet light, to which the ordinary photographic plate is most sensitive. A lens of this focal length will give an image very closely 5 inches in diameter, and since it was intended primarily for the inner corona it was considered that plates 14 inches by 17 inches would be of ample size to receive anything that could be obtained with a lens of the aperture ratio f 108 in the exposure time allowable. Owing to the length of focus it was impracticable to make the camera in one piece, and in consequence the two ends were made of wood, and the centre section of black cloth stretched over a light wooden frame work. The objective end was made 9 feet long so as to project far enough over the back of the 10-foot cameras for the cloth section to be out of the way of the operator. It was made about 8 inches square outside and 7 inches inside. This was the smallest dimension allowable to permit the full pencil of light from the objective to reach the edges of the plate without obstruction. The plate end was made 16½ by 19½ inches and 30 inches long, and was attached rigidly to the framework of the centre section ; its sides were panelled to prevent warping and shrinking of the wood. The construction of the centre section will be described more particularly when I come to speak of the erection of the installation.

The 10-foot Focus Twin Camera.

Two objectives each of 4 inches aperture and 10 feet focus were obtained from Grubb. One of these was corrected for the blue and violet light to be used with ordinary plates and the other corrected for wave length $\lambda 5500$, in the yellow green, to be used in conjunction with a yellow screen on yellow sensitive orthochromatic plates.

The equal focal length and aperture of these objectives readily permitted them to be mounted side by side, using two plates in the one holder forming a twin camera. This requires less mirror surface since the objectives can be placed nearly two inches closer together than if the cameras were separate, and also the services of one operator may be dispensed with. As it should be possible to obtain the outer corona with objectives of their aperture ratio $f30$, and an exposure of 30 or 40 seconds, 6½ by 8½ plates were considered the most suitable size, making the plate holder 8½ by 13 inches inside

measurement. The camera box was made 10 inches by 15½ inches, with a thin partition down the centre, and each half at the objective end was provided with a telescoping tube for adjustment to focus; all four sides of the box were panelled to prevent warping and twisting and it was lined all over inside with black velvet like the others. A recess was made in the back of the camera, containing the lens corrected for the yellow rays, to hold the screen which thus worked quite close to the plate.

The Cooke Camera.

The objective which, as before stated, was of 4½-inch aperture and 81·8-inch focus was to be used for obtaining tri-colour red and green and monochromatic green photographs of the corona, and since, owing to the absorption of the screens, the exposures for the same actinic effect would be much increased, a plate 4¾ inches by 6½ inches would be of ample size to accommodate all possible extensions around a ¾-inch image. The camera box was made similarly to the others, of whitewood, with a telescoping objective box for focussing at one end and a spring catch plate holder attachment at the other. A recess at the back was arranged to hold the screens, and provision also made for readily changing them.

THE SPECTROSCOPES.

The spectrum of the reversing layer was to be photographed by a concave grating and a prismatic camera. In these instruments no collimator is used, the thin shell or crescent of the gases surrounding the photosphere acting as a curved slit sending parallel light, in the one case, to the concave grating which diffracts the light and focusses it at the same time, forming the spectrum, and, in the other case, to the prisms which disperse the light, images of the crescent being formed in the focus of an objective placed just behind the prisms.

The Concave Grating Spectroscope.

The grating to be used is the dispersing part of a concave grating spectroscope of Rowland form and is of 4 inches aperture and 10 feet radius of curvature having a ruling about 3½ inches long and 1½ inches wide of 15000 lines to the inch. The manner in which this grating was to be used, *i.e.*, with parallel incident light, is quite different from the usual or Rowland way with slit, grating and camera on the circumference of a circle, and has been very strongly advised against by Wadsworth, Ap. J. XVIII., p. 77, who says the unsymmetrical aberrations are so great, except near the axis, that measurements made with it are untrustworthy. He supports this statement by mathematical calculations and by tables showing the amount of error introduced by gratings of different angular apertures at different distances from the axis. Even granting this to be so, although experiments here do not give so large an aberration, the error in the greater part of the length of spectrum used would be exceedingly small, and in the central three or four inches from λ4000 — λ5000 practically zero. Gratings used by Wadsworth, and by Frost, and by Mohler and Daniel, at the total eclipse of May 28, 1900, gave poor results, but Wadsworth's failure was due to the excessive angular aperture of his grating, and the others were due to defective focussing, and to their use of a flat plate, which could only be in sharp focus over a small portion of the curved focal field. In the case of the grating under consideration, however, the angular aperture is only ·43 of that of Wadsworth's and the aberrations would only be $(\cdot 43)^3$ or $\frac{1}{12}$ while it was determined to use a plate or film curved to correspond to the form of the field, and hence to overcome the difficulties by the observers just mentioned.

According to the theory of the concave grating the focal curve, when used with parallel incident light, is represented by the equation $r = \frac{\rho}{1 + \cos i}$ which for small distances from the axis is approximately an arc of a circle with a radius ½ that of the

grating. However, it was determined to try the grating experimentally, not only to examine the aberration away from the axis, but also to test the focal curve. Since it was impossible to use the grating in the same way as at an eclipse, with a thin crescent in the heavens, it was necessary to use a slit and collimating lens. The Cooke photo-visual objective, owing to its property of bringing all the coloured rays to the same focus, was very suitable for this purpose, and its tube was fitted with a slit in place of the eyepiece, which was brought into the focal plane of the objective by examining the image of a star or very distant terrestrial object between the slit jaws with a high power eyepiece, and adjusting the focus until both slit and jaws were equally sharp. The grating was mounted on a large table in its adjustable holder, and the camera box of the spectroscope was also mounted about 5 feet distant on the same table. The grating was turned in azimuth until its axis or the normal to its surface passed through the centre of the camera box. The telescope tube or collimator, using the carbon arc as the source of light, was then shifted to the proper angle, about 17°, to get the correct range of spectrum in the field. The first order spectrum on one side was especially bright, and the grating was turned so as to use this spectrum. The camera box, placed at right angles to the axis, was moved until the spectrum at the centre, examined through a high power positive eyepiece, was perfectly sharp. The position marked, the eyepiece was moved a short distance to one side, focussed and then again marked. This was continued until the positions of sharp focus for various points in the spectrum up to 4 or 5 inches on each side of the axis had been determined.

When these positions were plotted on paper, and a curve drawn through them (fig. 1), it was seen that the difference between the experimental positions and the arc of a circle of 30 inches radius was well within the limit of accidental error, and it was decided to make the plate or film conform to an arc of this radius, especially as this agreed with the focal curve given by the mathematical theory. In focussing the grating, the definition was carefully observed, and it was considered, in the writer's estimation, to be decidedly better than that which would be allowed by aberrations of the magnitude mentioned by Wadsworth. A photograph of the spectrum of the carbon arc reproduced in fig. 1 which was taken after the camera was completed, and was one of a series used to test the focus, confirms this opinion, and the chances of obtaining useful and accurate results with the grating used in this way, when properly adjusted and focussed, are extremely good. If, however, the spectrum was examined more than 4½ inches or 5 inches from the axis the definition rapidly deteriorated, and as the range of spectrum given in a length of 9 inches was from $\lambda 3800$ to $\lambda 6000$, considerably longer than could be obtained on any commercial orthochromatic plate with a reasonable exposure, it was decided to limit the length to this value, and to design the camera accordingly.

The flash or reversing layer, whose spectrum was desired, is of such a transitory character on or near the centre line of totality, that some means of making exposures in rapid succession is absolutely necessary in order to give a reasonable chance of obtaining it. The image of the sun given by the grating is $\frac{5}{8}$ inches in diameter, and, as the distance between the horns of the crescent will probably be less than the solar diameter, the width of the spectrum will probably not exceed $\frac{1}{2}$-inch. In such a case the method of making a number of spectra side by side, by simply sliding the plate holder the necessary distance between exposures, was chosen as offering the simplest and most direct solution of the problem. The focal curve, a circular arc of 30 inches radius, was too steep to use plates, so films were chosen and the plate holder and sliding mechanism were designed accordingly. The number of exposures required was nine, one each on the solar cusp before and after totality, one long exposure on the corona during totality, and three each on the 'flash' immediately after second and before third contacts. This fixes the size of the film at 9 inches by 9 inches, while the focal length 5 feet fixes the length, and the angle 17° to include the required range of spectrum the centre lines of the camera box. The photograph of the rehearsal gives a fairly good idea of the design of the camera complete. It consists of two intersecting tubes, the one 4 inches square inside, admitting light to the grating placed at the end

of the two tubes. At this end of the box is a removable cap on the side to insert the grating, which is pressed lightly yet firmly by springs against three adjusting screws passing through the end of the box. The light, after diffraction, passes along the second tube to the sliding plate holder at the other end (shown in fig. 8), where it is brought to a focus on the film. The plate holder attachment telescopes into this tube, and slides in and out for adjustment to focus. The plate holder itself moves back and forward across a slit 1 inch wide and 9 inches long, in the centre of the end of the back, which is opened and closed on the inside of the camera by a velvet covered flap shutter, actuated by a knurled wheel at each side of the attachment. The movement of the plate holder is given by two pinions gearing into rack on each side of the holder. These pinions, connected by a rod, and having knurled wheels at each side for turning, are of such a size that one-third of a revolution moves the plate holder exactly 1 inch. A spring catch, entering three equidistant notches in the circumference of a small wheel on the pinion shaft, fixes the necessary angular movement of the pinions and the corresponding linear movement of the plate holder. In making exposures the right hand at one side of the box may turn the wheel moving the plate holder while the left hand at the other side exposes by turning the shutter wheel, or vice versa, enabling exposures to be made in quick succession.

The plate holder is curved on the inside to an arc of 30 inches radius, and the film is held in contact with it by three or more narrow steel strips which spring into grooves on each side of the holder close to the film, and are so spaced as to come in the unoccupied intervals between the spectra. The whole arrangement worked admirably at the rehearsals, and there is no doubt that it would have behaved well during the eclipse.

The Prismatic Camera.

As the two single flint prisms of the universal spectroscope of the observatory were not required in that instrument, which used as dispersing medium the train of three prisms, it was decided to employ them in front of an objective for the same purposes as the grating spectroscope, to photograph the spectra of reversing layer and corona. The prismatic camera, owing to the loss of light in the various spectra given by a grating, can easily be made to give more intense spectra than a grating camera, and it was hoped with this instrument to get some details that the former could not secure. The prisms were two inches in height with a length of face sufficient to make a square field and in consequence an objective of 2½-inch aperture and 30 inches focus corrected for the photographic rays, was obtained. The minimum deviation for the central ray through the two prisms was 106°, and a simple box, shown in fig. 10, adapted to hold the prisms and objective and to send the dispersed light at this angle to a sliding plate holder, similar to that on the grating camera, was designed and constructed. The focal field of the lens was found experimentally to nearly coincide with an arc of 15-inch radius, and the back of the plate holder was curved accordingly, while the film 5 inches by 6 inches in size for 9 exposures on a spectrum ¼-inch wide was held to the curve in the same way as in the grating camera. The general design of this camera may be obtained from the photograph and drawing reproduced in figs. 10 and 5.

The Slit Spectroscope.

With this instrument, more particularly described under the observatory instruments, and used with the train of three prisms, adjusted to give a spectrum from D to beyond G, it was intended to photograph the coronal spectrum for the purpose of obtaining accurate measures of the wave length of its bright lines. A diaphragm was made to place in front of the slit, so that in one position the coronal spectrum could be photographed in the centre of the plate, and when moved to a stop a comparison spectrum of the sun would be photographed on each side of the coronal spectrum. The light for this spectroscope was to come from a concave mirror of 8½-inch aperture and 6 feet focus

placed on the south end of the coelostat axis. This mirror formed an image of the sun on the slit of the spectroscope, which was attached to its adapter so as to be easily rotated in position angle without altering the position of the slit or the angle of inclination of the collimator axis.

THE PHOTOGRAPHIC PLATES.

In order to insure the best possible results from the instrumental equipment, a proper selection of the most suitable plates for their respective purposes is most essential, and especially is this the case for the monochromatic photographs of the corona.

The Ordinary Plates.

The ordinary photographic plate, that sensitive to what are ordinarily called the actinic rays, the blue, violet and ultra violet light, is the kind adapted for use with the 45-foot and one of the 10-foot focus objectives, which are corrected for this region of the spectrum. But of ordinary plates all are not equally suitable, and they must be chosen to give the best results in the particular service for which they are employed. The corona, photographically is rather a difficult object as the light intensity of the inner corona is many times greater than that of the outer corona, which is itself considerably brighter than the extensions. Hence in an exposure long enough to give detail in the outer corona, the inner corona will be much over-exposed, and in order to prevent halation troubles on the dark background of the moon, it will be desirable to use a non-halation plate. The best type for the purpose is undoubtedly the double-coated plate with a rapid emulsion over a slow, thus promising more successful renderings of the strong contrasts of the subject. The Seed Nonhalation plate was chosen for this purpose, as it not only has a very high sensitiveness, the outer emulsion being, by the kindness of the makers, '27 Gilt Edge,' but it also has a very fine grain, as the experiments of R. J. Wallace, Astrophysical Journal XX., p. 113, have shown. In addition it was proposed to use, for some of the shorter exposures on these two cameras, the Ilford Monarch, backed to prevent halation, a new plate of exceptional rapidity combined with very fine grain and freedom from fog. Thus the choice of plates for this portion of the work was a comparatively simple matter, but it was quite another question when it came to the plates required for the monochromatic photographs of the corona.

The Colour Sensitive Plates.

Plates were required sensitive to four particular regions of the spectrum; to the yellow green $\lambda5500$-$\lambda5800$, for photographs by the visually corrected 10-foot focus objective; to green $\lambda5303$ for photographs by the light of the principal coronium line; to red, $\lambda5900$-$\lambda7000$, for photographs of the corona by red light and for the red three-colour record negative; to green $\lambda4900$-$\lambda5900$, for the green three-colour record negative—the blue three-colour record to be obtained from one of the negatives on ordinary plates.

Since, as is well known, the ordinary plate is only sensitive to light of shorter wave length than $\lambda5000$,—it is only by very prolonged exposure that the range can be extended further into the green—such a plate will not answer for any one of these four purposes.

On the other hand the regular commercial orthochromatic plate, usually sensitized with erythrosine, has, generally speaking, two bands of sensitiveness, one due to the silver bromide from $\lambda5000$ down, and the other due to the special sensitiser employed from $\lambda5500$-$\lambda5800$. This type of plate will answer admirably for the first range specified, but will again be entirely useless for the other three. A reference to the literature on the subject of orthochromatics did not render much assistance as no precise agreement seemed to exist as to the range of sensitiveness given by different dyes;

further, I could find no published results in regard to the sensitiveness of commercial plates, which it was desired to use on account of convenience and reliability, if a suitable make could be found.

It seemed, therefore, not only desirable but necessary to experiment myself with all the available brands of commercial plates, and also with plates stained with those dyes for colour sensitising, which from the experience of others promised the most hopeful results. To this end, a box, cabinet size, of every commercial orthochromatic plate obtainable in England and the United States, with some of French and German manufacture, was obtained, and a small quantity of each of the probably useful dyes was likewise procured.

As the light to be photographed at the eclipse comes, primarily, from the sun the solar spectrum is certainly the most suitable to test the colour sensitiveness of the plates. The Brashear Universal Spectroscope of the observatory is admirably adapted for the purpose of photographing spectra, and was accordingly employed in the tests. Although the prismatic spectrum does not correctly represent the distribution of the colours, as the blue and violet are too extended and the red and orange too condensed, still the greater convenience, its freedom from overlapping spectra, and its more general use in this regard, led to its choice in preference to the spectrum from a grating. The train of three prisms gave too much dispersion to include sufficient range, and the single dense flint prism, moved sufficiently out of its position of minimum deviation to include just the desired range, from $\lambda 7000$-$\lambda 3900$, or from C to K, was employed. As the most convenient and suitable means of obtaining a uniform intensity of sunlight on the slit, the spectroscope was attached to the equatorial telescope, and to reduce the quantity of light and heat to a reasonable amount the objective was diaphragmed down to 3 inches aperture; the sun's image being focussed on a piece of ground glass close in front of the slit to insure the complete filling of the aperture of the collimator. Uniform exposures for all the plates tested were given by a Thornton-Pickard roller blind shutter attached in front of the ground glass. Thus a comparative estimate of the absolute as well as the relative colour sensitiveness of the plate tested can be readily obtained. To save time and plates, a diaphragm with four openings was made to slide in front of the slit so that four exposures could be given, and four spectra could be made side by side on the same plate. With exposures of $1/25$, $\frac{1}{8}$, $\frac{3}{8}$, $\frac{3}{4}$, 2, 4, 8. 20 seconds. negatives were obtained serving admirably for comparison purposes. The great range of exposure given in each kind of plate showed much more readily and clearly than a single exposure could the relative colour sensitiveness of the various plates. Fig. 3 gives a reproduction of a few of the typical spectra and from these a general idea of the relative usefulness of the different plates may be obtained.

Plates Sensitive to Yellow Green $\lambda 5500$-$\lambda 5800$.

For the first range of sensitiveness specified, from $\lambda 5500$-$\lambda 5800$ a number of plates were found to satisfy the required conditions and of these the most sensitive to the yellow green were, the Ilford Rapid Isochrom, the Edwards Snapshot Isochromatic, the Cramer Instantaneous Isochromatic and the Seed Orthochromatic. A further comparative test of these plates, with and without a yellow green showed that, although all four gave high sensitiveness to the yellow green, the Cramer Instantaneous Isochromatic was probably the best and it was accordingly chosen for the purpose. Fig. 3 shows exposures of $\frac{1}{4}$ second on the Cramer and Ilford plates without and with screens.

Plates Sensitive to Coronium Light $\lambda 5303$.

As regards this region in the spectrum no commercial plates tested were found to be sufficiently sensitive to give any hope of useful results, if employed to obtain photographs of the corona by this light. The best were the Cadett Spectrum, the Hammer Orthochromatic and the Mawson Orthochromatic B. Spectra on those plates are

reproduced in fig. 3, and it can readily be seen, if the region around λ5300 were solely employed, that very little impression would be made on these plates. I had hoped, before the tests were made, to find a plate having, besides the usual bands in the blue and the yellow green regions, a strong band of sensitiveness with a maximum about 5300. The Hammer Orthochromatic shows traces of such a band but it is by no means sufficiently pronounced. If such a plate had been found, the difficulty of making a suitable screen, of which more anon, would have been considerably lessened.

The original method of sensitising plates, by bathing ordinary plates in weak solutions of certain aniline dye stuffs, commercial plates being prepared by incorporating the proper quantity of the dye in the emulsion, still remained to be tried. Hundreds, I might also say thousands, of aniline dyes have been tested as colour sensitisers, and of these scores have been recommended as useful for the purpose; but the most contradictory results have been obtained by different experimenters with the same dye. As it was hopeless, in the time at disposal, to attempt to repeat all these experiments, it was determined to choose those dyes that were specifically claimed by reliable authorities to sensitise in the required region. By far the most systematic and thorough experimenters in this field are Eder and Valenta, who between 1884 and the present time, have tested and tabulated the effects of several hundred dyes used as sensitisers for dry plates. Of this number perhaps a dozen gave reasonable promise of fulfilling the required conditions, and samples of these were procured and tested.

These may be divided into three classes:—

1. Certain yellow dyes claimed to sensitise in the green.
2. Dyes rendering plates sensitive to red.
3. Dyes rendering plates sensitive to all the spectrum colours, or panchromatic.

The first class among which were Titan, Canary and Cotton Yellow from Holliday, Nitrophenine from Clayton, and Thiazol Yellow from Bayer proved very disappointing. Eder and Valenta have published spectrograms made on plates sensitised with these colours showing a closed band between D and G with a maximum about E. The results of the tests made here seemed to indicate either that the dyes used were not the same or that such spectrograms must have been the result of considerable over-exposure, as the only effect of the dye seemed to be to diminish the violet sensitiveness, and to displace the blue slightly towards the green, while in no case did it get beyond *b* except with very prolonged exposure. A spectrum showing the effect of one of these dyes as a sensitiser is reproduced in fig. 3. The second class although sensitising for red, gave no useful effects in the green where it was required, and they were accordingly dismissed in favour of the panchromatic sensitisers of the third class.

Three of these, Ethyl Red, Orthochrom T, and Pinachrom, all of the same group of chinaldin-cyanin derivatives, the German name of Orthochrom T, being p-Toluchinaldin-p-Bromchinolincyaninaethyliodid gave very promising results. Plates, carefully sensitised and handled, were tested, all showing that the last-mentioned Pinachrom (from Meister, Lucius and Brüning, Höchst am Main) was on the whole the most satisfactory, giving considerably more sensitiveness and less liability to fog than the other two. As the reproduction fig. 3 shows, the band of sensitiveness is nearly uniform from C to H, with traces of three maxima, one at or above D, one at E, and the third in the silver bromide region between F and G. Three different makes of rapid ordinary plates were tested with Pinachrom, the Lumière Extra Rapid, the Seed 'R' and the Ilford 'Monarch.' Of these the Seed showed slightly more tendency to fog while the Lumière was decidedly less sensitive than the Monarch. The latter was also more rapid than the Seed.

An Ilford Monarch plate stained with Pinachrom is very well suited for photographing by light of wave length λ5300 being about ten times more sensitive in that region than the best of the commercial plates, Cadett Spectrum or Hammer Orthochromatic. When used with a suitable absorbing screen to prevent the other colours from acting on the plate, the chance of obtaining a record of the distribution of coronium is very good, as the probable increase of exposure required is only about 25

times that on ordinary plates and this is well within the allowable limit with a lens of fairly large aperture.

A Pinachrom sensitised plate gives also excellent panchromatic effects and is hence very suitable for photographing the spectrum or for three-colour photography. Outside of the application of the former in general spectroscopic work it has also a direct bearing on the work to be done at the eclipse for the photographs by the three spectroscopes were to include the range of spectrum for which Pinachrom sensitised. An Ilford Monarch celluloid film was sensitised and tested in the concave grating objective camera using the carbon arc as the source of light and a reproduction of the spectrum obtained is given in fig. 1. It will be seen that it is not only entirely free from fog but also gives, taking into account the greater intensity of the carbon light in the violet and ultra-violet, a spectrum remarkably uniform in intensity from $\lambda6100$ to $\lambda3800$. It was proposed, therefore, to use Monarch films sensitised with Pinachrom for the Prismatic and Grating cameras and Monarch plates similarly sensitised for the slit spectroscope.

For plates sensitive to the other two regions required, in the red and green for the three-colour record negatives no plates tested were one-tenth as sensitive as those stained with Pinachrom and there was hence thought to be a very good chance of obtaining successful negatives. Indeed there had been no intention of trying to obtain such records, as it would be practically hopeless on the commonly used plates, until the tests of Pinachrom showed its special suitability for the purpose.

THE FILTERS OR COLOUR SCREENS.

As it is impossible to obtain photographic plates sensitive only to the required region of the spectrum, some sort of absorbing medium is necessary for each of the four ranges specified above to prevent light other than the desired colour from reaching and acting on the plate. Such an absorbing layer usually a transparent coloured substance, generally called a colour screen or filter may be made in various ways. It may be of coloured or stained glass; it may be a coloured liquid in a glass cell; or it may be stained collodion of gelatine films. Whatever form it may take the tint must be uniform throughout, and, to prevent distortion, it must be contained within plane and parallel glass walls. If coloured glass could be procured of the desired absorption it would be preferable to any of the other forms as it could be thinner and would not fade as some stained films are liable to do. Unfortunately, however, the range of absorptions obtainable in coloured glass is very limited and in several of these the colour is not pure but so mixed with black as to exercise a general absorption as well as in the special region for which it is adapted. This, of course, diminishes the intensity of the light and unnecessarily increases the exposure. Coloured liquids contained in glass cells can easily be made of any required absorption, but they are so troublesome and dirty owing to evaporation and to spilling of the liquid as to be quite unsuited for work in the field. Moreover they are thicker than dry filters and considerably less permanent and have to be retested for absorption every time the solution is replenished. Of the two other forms of filter, stained collodion and gelatine films, the latter was chosen as being more reliable and permanent and the colouring matter was applied by bathing a gelatine coated plate in a solution of the required dye. The G. Cramer Dry Plate Co. coated a number of pieces of thin plate glass 8 inches by 10 inches in size with an even and uniform layer of pure gelatine, which answered the purpose admirably.

In order to have some idea of the most suitable dyes for making the four filters required a number of test plates of the different colours available were made. Ordinary unexposed gelatine dry plates were fixed out, washed and dried and then cut into pieces about 2 inches square. Three or more of these test plates were stained of different intensities, weak, medium and strong in solutions of each of the dyes and these could then be readily examined spectroscopically to determine the absorptions of the colours. The preliminary examinations were visual with a small direct vision spectros-

cope, while the final test was invariably photographic with the same arrangement as that used in testing the photographic plates, the dyed strip being placed in the course of the light near the slit.

The Yellow Screen.

In making the yellow screen a number of yellow and orange dyes were examined for their transparency to light of long, and opacity to, light of short wave length. Tartazine made by Bayer of Elberfeld was decidedly the best of all tested, and is, in weak concentrations, of a beautiful yellow colour becoming more orange-yellow when used in strong solutions. It transmits red, yellow and yellow-green light almost undiminished in intensity, and absorbs violet light completely and blue in proportion to the strength of the solution or depth of stain. A single layer of gelatine stained with a saturated solution of tartazine absorbs up to wave length λ5200; if it is desired to carry the absorption further into the green more than one layer of the gelatine is required. However, for the yellow filter for the Cramer Instantaneous Isochromatic, it was not necessary to absorb even so far as this, since this region comes in the band of insensitiveness of the plate. A screen absorbing light below λ4900, or at the most λ5000, is as deep in colour as is necessary to prevent the blue rays from acting on the plates. This limit was finally tested by photographing the spectrum of sunlight on these plates through screens of different intensities, and the filter was made to correspond to the lowest intensity which showed no silver deposit in the blue part of the plate. The purpose of the filter being only to prevent the blue and violet light from acting on the plate, the weaker it can be made, provided this end is fulfilled, the better, for it will then transmit a greater proportion of the yellow green light: a moderately strong solution of tartazine was made and filtered and one of the 8 x 10 coated plates bathed in it until, as nearly as could be judged of the same intensity as the chosen test plate. When dry it was tested photographically, one test each on a Cramer and an Ilford plate being reproduced in fig. 3, and changed by dyeing more deeply or soaking out some of the dye in clear water, until it was exactly the right intensity. It was then carefully put away until the other filters were ready.

The Monochromatic Green Screen.

This was by far the most difficult screen to make, for, not only had the absorption on each side to approach as close as possible to λ5303, but also the finished screen must be as transparent as possible to light of this wave length or else the exposure required to get the necessary details would be too long. If a plate could have been obtained with a narrow band of sensitiveness having its maximum at this point, the problem would have been much simplified, but, as already seen, no such plate could be found, and by far the most sensitive in that region was a plate stained with Pinachrom. Its range of sensitiveness, however, is quite uniform all along the spectrum from λ6000 to about λ4000, and hence the screen must be such as to absorb everything practically but λ5303. No one dye, especially in the green, would give the desired effect, and two dyes must be used, one absorbing the blue and the green as far as λ5250, and the other absorbing the red, yellow and the green as far as λ5350. The former would be a yellow and the latter a green dye. For the yellow no dye was found to answer so well as tartazine, and a very densely stained plate was found to absorb fairly sharply to about λ5250, and to transmit the balance of the spectrum without too much diminution of intensity. For the green, however, the problem was more difficult. Of the twenty green dyes in my list and of which I had specimens, only three or four gave any promise of answering the purpose, and none of these absorbed as sharply as I would have liked, so that to get the complete absorption to the required limit entailed a partial absorption of λ5303. Photographic tests finally reduced the suitable dyes to two, Brilliant Acid

Green 6B and Alkali Fast Green G, both by Bayer, of Elberfeld; and the final choice of these was not made until they were combined with the tartazine stained screens. In fact two filters were completely finished and then finally tested. The one made with one film of Brilliant Acid 6B and two films of dense tartazine, gave a purer monochromatic screen than the one made from one film of Alkali Fast G and one film of dense tartazine, but the general absorption was so much greater and the exposure required so much longer that the latter was finally chosen for the work. Fig. 3 shows reproductions of spectra taken on plates stained with Pinachrom without a screen, and with three monochromatic screens, although light of other wave lengths near λ5303 affects the plates, still it is of comparatively small intensity. Moreover, no other line in the emission spectrum of coronium but λ5303 can affect these plates, and the quantity of continuous coronal spectrum embraced in the region transmitted by these screens is so small in proportion to the quantity in this bright line as scarcely likely to affect the character of the photograph.

The Three-colour Red and Green Screens.

As before stated, the limit for the red screen transmission is between λ5900 and λ7000, and for the green between λ4900 and λ6000, with the absorptions ending somewhat gradually. No single colour could be found for either of these screens, and consequently like the monochromatic green, they were made of two plates. For the red screen erythrosine was found to be a very suitable colour although the absorption began rather abruptly at the yellow side. However, this was deemed an advantage in this case, as although not appreciably affecting the value of the negative as a three-colour record, it would render it more useful as a monochromatic red record of the corona. But erythrosine transmitted blue and violet as well as red, and this had to be absorbed by a second plate of tartazine. The screen as finally completed transmitted red and orange red as far as λ5900, while it entirely absorbed all the colours from orange down. The green screen also required two plates, one of a green dye and one of tartazine to absorb the blue transmitted by the green. The most suitable dye was found to be Acid Green 2G Extra, by Bayer, and of a comparatively weak concentration. It absorbed the red and violet and transmitted the rest, while the grading of the absorption in the orange and red was very suitable. When the screens were finally completed and cut to size they were sealed with Canada balsam. The yellow screen was cut 6½ by 8½ inches, and as only one film was needed a piece of thin plate glass was sealed to the film side of the screen. For the other three screens, size 5 by 6¾ inches, the components were sealed film to film. The balsam employed was a very white clear article used in three-colour work, and after the sealed filters had been allowed to set thoroughly they were bound up with lantern-slide binding strip. The finished screens were beautifully even and transparent, and I have no doubt would have performed admirably.

In order to be able to intelligently estimate the relative exposure required, when these screens were used, compared to that of unscreened plates, a series of tests were made on the plates with which they were to be employed. These tests consisted of exposures of suitable lengths with and without screens on a piece of crumpled white blotting paper pinned on a background of black velvet and so placed as to show both lights and shadows. A comparison of the density of the resulting negatives, which were all developed together, readily enabled one to estimate very closely the relative exposures required. It was found that for the yellow screen on Cramer Instantaneous Isochromatic plates from 3½ to 4 times the exposure without a screen was required. For plates stained with Pinachrom it was found that: The Monochromatic Green required 20 to 25 times normal exposure; the Three-colour Green required 10 times normal exposure; the Three-colour Red required 12 times normal exposure. So that 60 seconds with the monochromatic green on the Cooke lens *f* 18 which was one proposed exposure should give the same actinic effect as 108 seconds in 45-foot camera, and about 10 seconds in 10-foot camera, which is quite sufficient to get detail in the outer corona.

PRELIMINARY PREPARATIONS.

It is very necessary, before starting on an eclipse expedition to mount, adjust, and test the instruments under as nearly as possible the same conditions as will prevail in the field. Only by so doing can the most thorough preparations be made, and difficulties, which would not otherwise show themselves, be met and overcome. Evidently the first step before erecting the coelostat or cameras is to calculate the azimuth in which the latter are to be placed and the position of the sun at totality. Since the cameras are to be placed horizontally, at sunrise the coelostat mirror will be vertical and also since it is in the meridian the reflected beam will be as far south of east as the sun is north of east. The latitude of Northwest river is about 53° 31′ 30″ and the declination of the sun at totality 9° 9′ 20″. The azimuth of the sun at sunrise will be 15° 33′ north of east, and at totality, 7 hours 51 minutes, about 18° south of east. The altitude at totality will be about 24° and the azimuth of the reflected beam or of the cameras 15° 33′ south of east. The sun's light, proceeding to the mirror, will pass almost directly over the cameras which must hence be placed far enough back so as not to cast any shadows upon the mirror. Further, since they are all grouped together and as, owing to the changing declination of the sun, some movement in azimuth is desirable for the purposes of adjustment and focus, it was determined to mount them all on one base and a plank 10 feet 6 inches long, 24 inches wide and 3 inches thick, built up of 24 whitewood strips, 3 inches wide and 1 inch thick glued together, was obtained on which to mount the cameras and spectroscopes. It was proposed to place this baseboard at Northwest river on two cement piers about 8 feet apart, but for the preliminary tests at Ottawa it was placed on temporary wooden stands.

FOCUSSING THE INSTRUMENTS.

Before mounting the cameras, even temporarily, on the base each one was separately focussed. The objectives were mounted in their telescoping boxes, and an approximate focus was obtained by pointing them at a distant terrestrial object and viewing the image on the ground glass provided for each. They were then strapped to the tube of the equatorial telescope, and the final focus determined from a series of exposures, at different distances of the objectives, on stars trailing across the field. This method gave the focal point very exactly, a movement of $\frac{1}{16}$-inch in the 10-foot focus lenses or one part in 2000, made a recognizable difference in the sharpness of the trails. The focus of the objectives, which were to be used with screens, was determined through their respective screens, and the positions of sharp definition in all were carefully marked and noted. Owing to the grain of the wood running lengthwise in the cameras it is unlikely that any change in the position would occur. It was not, of course, possible, nor would it be worth while to focus the 45-foot camera in this way, as it had no fixed length and it was not focussed until finally installed at Northwest river.

The concave grating and prismatic cameras were focussed, primarily, by the collimator and slit previously used in determining their focal curves, and this position was further tested by photographing star spectra. These cameras were also rigidly attached to the tube of the equatorial and a series of exposures, varying the focal distance, were made on the spectra of Vega, Arcturus, Jupiter and Venus, guiding being accomplished by the micrometer wires in the telescope. The positions of sharp focus found by the two methods agreed very well though the latter was preferably followed, as more nearly approaching the conditions obtaining during totality.

CAMERA HUT AND DARK ROOM.

Some kind of portable and removable covering for protection against the weather was necessary for the coelostat and cameras, also a dark room where the plates could

be safely stored and handled. The conditions to be fulfilled in the case of the camera hut were portability and ease of removal of roof and sides to admit the sun. After considerable thought it was decided to use a canvas fly for a roof, stretched over a wooden framework and walls. It was made 20 feet long and 9 feet wide with walls 5 feet high. The posts were made of 4-inch x 4-inch and the sills and plates of 2-inch x 4-inch stuff, all framed carefully together and fastened with screws. The side walls were made in sections, 6 to each side, each about 3 feet 4 inches wide and 5 feet high, of ⅞-inch matched siding nailed to battens at top and bottom, which were in turn fastened to the sills and plates by a couple of screws. The west gable end was nailed up solid, while at the east end the gable part was hinged to the end wall, and easily let down to a horizontal position when required to admit the sun. Beside the end rafters were two others each hence 6 feet 8 inches apart. The ridgepole was in two pieces, and the easterly half with the east rafters could easily be unhooked and taken away, while the westerly part attached to the west gable, served to stiffen the whole roof. The fly, which was readily pulled over the roof by long guy ropes, was re-inforced wherever it rested on the frame work to prevent leakage, and was made about 3 feet longer each way to allow plenty of overlap for the same purpose. When required to admit the sun, it was either pulled off altogether, or simply rolled back to the west end out of the way of the sun, the gable end was let down and the ridge and rafter removed, the whole process only taking about two minutes. The arrangement worked admirably and was very convenient and satisfactory. The side walls could also be readily removed by taking out the screws through the battens and taking away as many sections as desired. An idea of the design may easily be gathered from the illustrations (figs. 7, 8, 9 and 10). The dark room was a simple frame structure 8 feet square with a sloping roof, made of matched stuff and covered with tar paper. It had a small window opening in which was fastened a safe ruby light, and had a developing bench and shelves, while it was floored so as to be thoroughly dry for the safe storage of the plates.

The camera hut was built on a level spot north of the observatory, and, as soon as it was finished, the coelostat was erected on a cement base inside. It was carefully adjusted and the clock rated both by timing and by observing the steadiness of the images in the cameras. The baseboard for the cameras was placed on temporary wooden stands at the right height and the cameras placed in position and temporarily fastened. The installation was then carefully tested in every possible way with the sun, under as nearly as possible eclipse conditions, to allow any defects in design or construction to manifest themselves at a time when they could be easily remedied. When everything was satisfactory the instruments were taken down and carefully packed for shipment. The camera hut and dark room were all marked to facilitate re-erection and were then taken apart and crated in bundles of convenient size. All the materials and supplies which there was any possibility of requiring were gathered together and carefully packed. Altogether for the instrumental work there were 88 boxes, bundles and crates weighing in the neighbourhood of five tons. I wish to acknowledge here the very able and skilful assistance of Mr. W. P. Near who not only helped very materially in the preliminary preparations at home, but who brought a great deal of ability and energy to play in the erection and adjustment of the installation at Northwest river. Without his able help the work must have proceeded much more slowly and the preparation could not have been so thorough and complete.

FINAL ERECTION.

The ss. *King Edward* reached Northwest river on Friday morning, August 11, and after we had landed and looked over the ground there was no difficulty in choosing a suitable site for the camp as the level plot of ground close to the beach, east of the Hudson's Bay Company's post, was an ideal spot both for a camping ground and for an observing station. The instrument and camp supplies had all been landed by Saturday morning early, and the installation of the camp proceeded apace. It was nearly half a

mile from the wharf to the observing station, and all the instruments and supplies had to be wheeled or carried this distance. The usefulness of the two-wheeled hand cart, which I had taken care to provide, showed itself, for without it there would have been the greatest difficulty in moving the heavier boxes. I cannot forbear here from speaking of the splendid way in which Mr. Macara not only looked after the moving of the stuff, but actually took the lion's share himself. If it had not been for his energy and zeal not only would our own preparations have been much delayed, but the camp arrangements and the preparations of other members of the party have been hindered. But his efforts did not end with the transport of instruments and supplies, for, as soon as that was finished, he showed his ability and energy in a marked way in the construction work.

For convenience in installing our equipment, a piece of fairly level ground, preferably rising slightly to the east, was necessary, and a suitable site was easily chosen on Saturday morning, a photograph of the completed camp being reproduced in fig. 6. The direction of the central line of hut and cameras, which was 15° 33′ south of east, was kindly given me by Prof. Stewart, and from this line the positions of the coelostat, camera and spectroscope piers, which are shown in the accompanying plan, fig. 4, were laid out. The construction of the piers was the first thing undertaken, and casings were soon knocked together and the filling in started. The foundations of the coelostat and rear camera pier were filled in on Saturday while on Monday these were finished and the other two well under way. When not engaged in cement work, the frame of the camera hut was put together away from the piers, to be carried into position later when they were finished. On Tuesday the dark room was erected, Dr. Chant in this and other work giving able assistance, and on Wednesday the piers were finished, the hut placed over them and the coelostat unpacked and erected.

The central section of the long focus camera was next undertaken. The tube was composed of nine frames of 1½ inches square stuff, 24 inches by 24 inches outside measurement, which were held together about 4 feet apart and the section made rigid and continuous by nailing strips 4 inches by ⅞-inch lengthwise along the corners of these frames, thus forming a tubular framework about 33 feet long. This tube is seen in the cut of the construction work, fig. 7, installed in place on supports about 4 feet from the ground. These supports were made sufficiently wide to allow the plate-holder end, which was of box form and rigidly screwed to the centre section, to slide about three feet north and south. The purpose of this range of movement was to permit the use of celestial objects for testing of focus whose declination differs slightly from 9° 10′, the declination of the sun at the time of eclipse. The frames of the supports were continued up and over the tube, and were then covered on top and sides with tar paper to keep out the rain, and as a further security against the entrance of light. The tube itself was entirely covered with black cloth so closely woven as to be practically light tight, while the frames and connecting strips were painted dead black. The tube was carried through the east end of the camera hut projecting about a foot, and was then connected with the objective end of the camera, which itself projected back over the twin camera about a foot, by more black cloth stretched between, a space of about 18 inches. The cord from the shutter was led back along the roof of the supports through screw eyes to the plate holder end, where it terminated in a convenient position for the operator. It was not thought necessary to build a pier for the plate holder end, as it was amply steady on its braced supports, and as there was no possible chance of vibration being transmitted between the sections by the flexible cloth connection.

The two cement piers, on which the camera base board was to be placed, were each about 33 inches long, 15 inches wide and about 3 feet high. Their centres were 8 feet apart, and each pier had a scantling built into the top, planed off so that the baseboard rested perfectly level. When the final position was obtained the base was to be firmly bolted to these scantlings so that everything would be perfectly rigid and stable. The extra length of the piers over the width of the base, and the extra length of the base over the distance between the piers allowed considerable range of adjustment end-

ways and sideways, the former to allow the cameras to be placed as near to the mirror as possible without interference from shadows, and the latter allowing shifting in azimuth to get objects of different declinations for focussing purposes.

This base board was in position ready for service on the 16th and the cameras and spectroscopes were firmly attached to it and to each other by small angle irons and screws, and in the case of the prismatic and grating cameras by wooden braces. The position and method of attachment of the cameras is readily gathered from the illustrations, figs. 8 and 10, and plans, figs. 4 and 5. The twin camera is at the bottom, above this to the south the objective end of the 45-foot focus, then the Cooke, and to the north the grating and prismatic cameras. These were inclined at an angle of 40° with the vertical, so that the refracting edge of the prisms, and the lines of the grating were nearly parallel to the tangents at the second and third points of contact.

The slit spectroscope was attached to its adapter, to allow it to be readily rotated in position angle without disturbing the inclination, in order to get the brightest part of the corona tangent to the slit. The adapter was screwed into a cast iron flange which was attached by clamp and abutting screws, to allow adjustment, to a strong oak frame built to the correct angle, and bolted to the spectroscope pier, the position and arrangement being shown in fig. 8. The spectroscope itself was by this means placed at such a height, and adjusted to such an angle, that the light from the sun, after grazing the top of the frame, would be reflected back from the concave mirror forming an image of the sun on the slit of the spectroscope. The angles of incidence and reflection became by this means a minimum, and the deviation from normal incidence small enough so as not to appreciably affect the definition in the solar image. This image was brought to any desired position on the slit by two slow motion rods, connected to the screws by universal joints, and led to a convenient position for the observer, myself, near the spectroscope.

ADJUSTMENTS.

The top of the coelostat pier was very carefully levelled, and after the lower section of the column had been put in place, its planed upper surface was again carefully tested by a five-second level, and brought as nearly horizontal as possible by wedging up slightly where required. The axis was brought to the correct altitude by the graduated arc, on the sector, and then the only thing remaining was to get it into the meridian. An east and west line was run through the centre of the mirror, and a theodolite, placed about a hundred yards east and on the same level, was used for observing the reflection of its own telescope in the vertically placed coelostat mirror. The adjusting screws, provided in the column, were then used to shift the instrument in azimuth until the reflection was in the centre of the field. Evidently the mirror and consequently the axis can not then be very far from the meridian. This adjustment and that of the altitude can be readily tested, and were so tested by focussing an image of the reflected sunlight in the long focus camera, and observing any change in its position during a run of the clock of an hour or more. There was no appreciable shift in the position of the 5-inch image during that time, showing conclusively that, not only was the instrument well adjusted, but the clock closely rated.

The shorter focus cameras with the prismatic and grating cameras had already been focussed, but it was desirable to again test this adjustment and it was necessary to accurately focus the 45-foot camera which had not as yet been determined in any way. As its movement in azimuth was only about $3\frac{1}{2}°$, celestial objects whose declinations were between 8° 30′ and 10° 30′ could only be used, the declination of the sun at the time of eclipse being 9° 9′ 20″. The only bright star between those limits is α Aquilae, Altair, whose declination is 8° 37′ and which was in a suitable position for observation in the early evening. The declination of the sun only reached 11° on Friday the 25th, hardly leaving sufficient time after allowing for bad weather, and besides the sun is not very suitable for determining the focus. The declination of the moon was only within the required range on one evening, Sunday, the 20th, and, as

it was a suitable object, it was decided to use it if possible on this evening. A preliminary test with Altair on Saturday evening showed the limits within which the true focus lay, but the star was too bright, gave too broad a trail, to accurately determine the correct position. The moon rose about ten o'clock on the 20th, and was in a suitable position to use between 11.30 p.m. and 3.00 a.m. But unfortunately the sky was too cloudy to make any successful exposures. Although on the Monday night the declination had risen to nearly 12°, it was determined to get the image on the plate by shifting the coelostat in azimuth, and, as the night was fine, two plates with four pictures on each, were successfully exposed, giving the position of best focus quite accurately.

In addition the moon was photographed in the other cameras, using colour screens where proposed, and the agreement with the previous focal position, obtained by star trails at the observatory, was excellent. Later on in the week, the cameras were all again tested by allowing Altair to trail suitably diaphragming the apertures to get the faint trails necessary for accurate estimation. Since no change in focal position in the cameras had been noticed, it was not thought necessary to redetermine the focal positions of the prismatic and grating cameras, especially as the spectrum of Altair, the only star bright enough, was of the first type with broad diffuse lines not at all suitable for accurate determinations.

After the focus had been thus carefully determined, each of the objective boxes of the cameras, and the sliding backs of the spectroscopes were firmly screwed into position, and I felt satisfied of the correctness of the focal distance to within $\frac{1}{20}$-inch in the case of the shorter focus cameras, and $\frac{1}{4}$-inch in the case of the 45-foot.

MISCELLANEOUS DETAILS.

The focussing was finally completed about the 25th, and the remainder of the time was spent in perfecting the numerous details in the working of the apparatus, and in arranging devices for facilitating speed in manipulation, and for avoiding accidents. It was found, in practising with the changing of plate holders, drawing of slides, &c., that considerable time, especially in the larger sizes, was lost in inserting the slides in the holders, that they were liable to enter crooked and stick, thus losing precious seconds, and entailing danger of fog. A very ingenious device of Mr. Macara, who was entrusted with the working of the 45-foot camera, entirely overcame this difficulty. A piece of wood with a groove in it was nailed on the same level as the bottom of the slide, which pulled out in this groove to a stop at the end preventing its complete withdrawal. The slide was simply pulled out to the stop with one hand, the exposing cord pulled with the other, and the slide immediately shoved back home as soon as the shutter was closed, saving three or four seconds each exposure, and enabling two more exposures to be made in the given time. This device was also applied to the twin camera operated by Mr. Near, and here also its use allowed two additional exposures.

The specially sensitised plates for the Cooke camera and films for the prismatic and grating cameras, which were preferably prepared shortly before using, were carefully sensitised on Monday evening, the 28th, and dried in a specially prepared calcium drying box. On Tuesday one of each was carefully tested for colour sensitiveness and freedom from fog, by photographing blotting paper on black velvet through the different filters, and was found practically perfect. I felt quite satisfied, therefore, that, so far as instrumental equipment and the photographic materials were concerned, everything was in the best of shape.

REHEARSALS.

The only other factors requisite for success were good weather conditions and practice of the various operations of totality. Although we had no control over the former, the latter was very important. Besides Mr. Macara, Mr. Near and myself three more operators were needed. Of these two, Mr. Howell and Mr. Maybee, came

with the second party which arrived on the 28th, and Prof. Stewart kindly consented to take the Prismatic Camera. The names of the operators, with their instruments and proposed exposures are as follows:—

J. Macara—45-foot Camera—

Six exposures on Seed Non-Halation and Ilford Monarch plates of 3, 5, 10, 40, 20 and 15 seconds, respectively.

W. P. Near—10-foot Twin Camera—

Nine exposures on two plates each, one Seed Non-Halation by photographic objective, the other Cramer Instantaneous Isochromatic by visual objective through Yellow Screen exposures of 1, 2, 4, 7, 10, 40, 20, 15, 3 seconds, respectively.

D. J. Howell—81·8-inch Cooke Camera—

Four exposures on Ilford Monarch plates sensitised with Pinachrom.
One exposure 10 seconds through three-colour green screen.
One exposure 12 seconds through three-colour red screen.
One exposure 60 seconds through Monochromatic green screen.
One exposure 20 seconds through Monochromatic green screen.

J. E. Maybee—Concave Grating Objective Camera—

Nine exposures on Ilford Monarch film sensitised with Pinachrom.
One exposure, instantaneous, on Solar cusp shortly before totality.
Three exposures, ¼-½ second each, on Flash Spectrum immediately after totality.
One exposure, about 2 minutes on Coronal Spectrum during totality.
Three exposures, ¼-½ second each, on Flash Spectrum just before third contact.
One exposure, instantaneous, on Solar Cusp immediately after totality.

Prof. L. B. Stewart—Prismatic Camera—

Same programme as Mr. Maybee.

J. S. Plaskett—Slit Spectroscope—

One exposure on Ilford Monarch plate sensitised with Pinachrom on spectrum of corona throughout the total phase. The slit to be set tangent to the brightest point of the corona image produced by the concave mirror. A comparison solar spectrum to be formed on each side of coronal spectrum immediately after totality.

The two illustrations of the rehearsals (figs. 9 and 10) show each operator in position at his instrument. Each one practised with his own programme until he could perform it satisfactorily. On the morning of the 29th a complete rehearsal was held under as nearly as possible the same conditions as would prevail at the eclipse. The signal was given for totality, after a warning 30 seconds previous, and then the time was called every ten seconds until the 150 seconds had elapsed, the intermediate intervals being given by the beats of a metronome. So well had every one practised that the first rehearsal went through without a hitch. The following rehearsals served to perfect the movements, until, after fifteen or twenty, the whole programme went with machine-like regularity. Another set of rehearsals was held in the evening by lantern light to accustom the operators to working by artificial light which might be required during totality. These went even better than the morning ones, and I felt satisfied that every thing would go smoothly. After rehearsal the plate holders were carefully loaded and numbered by Mr. Near and myself and every thing was ready for the eventful morning.

Although the prospects for fine weather on the previous day had been very poor, rain with a continually falling barometer, we still hoped, even against our better judgment, that it might clear up for the time, but at daylight on the 30th, although the clouds were more broken than on the previous day, there did not seem much chance of observing the eclipse. However, all preparations were made, the plate holders placed in order in their positions on the stands provided for them, the canvas roof rolled back, the gable end dropped, and the ridge and rafter removed. The computed time of second contact was about 7.51, and at 7.30 although there was no perceptible differ-

ence in the density of the clouds, one could notice a diminution in the brightness which became more and more marked as time went on. About twenty minutes before totality, when it was seen there was no possible chance of the clouds breaking, I set up my camera and made a number of exposures of graded length to get some idea of the relative intensity of the light during the eclipse. As a result of carefully comparing the exposures given and intensities produced on these negatives, it may be said that—

Intensity	20 minutes before	totality was	1000	times	that during totality.
"	10 "	"	650	"	"
"	6 "	"	200	"	"
"	4 "	"	120	"	"
"	2 "	"	45	"	"
"	20 seconds after	"	15	"	"

The exposure required during totality to get the same density of negatives was about 10,000 times that required on a bright day at the same hour.

Visually, however, the darkness during the total phase was not so great as I had expected, it being very considerably lighter than a night with full moon. The darkness at first seemed very gradual in its approach until about five minutes before totality, when the obscurity increased more rapidly. The time of totality could not be mistaken as there was a rapid onrush of darkness which was very perceptible and awe-inspiring. The return of light seemed much more rapid than the diminution, but that may probably have been an illusion. Of that I have no means of judging.

Naturally it was a bitter disappointment at having practically no result for six months' work, except the experience in preparation and the useful knowledge gained of colour sensitive plates and absorbing screens. If everything had not been in such first-class shape for the observations, if the perfection of adjustment to focus and working of the camera shutters and plate holders, if the running of the coelostat, or the quality of the specially sensitised plates had not come up to my required standard, probably I would not have felt the disappointment so keenly; but, when the prospects of obtaining some original and useful results were so good, it seemed too bad there was no chance to try.

However, nothing remained to be done but dismantle and pack up all the instruments and appliances. This was entered into with such vigour that little remained to be packed after the evening of the 30th. The rest of the packing was done on the morning of the 31st, and by evening everything was loaded on a schooner in readiness to be transferred to the steamer.

I cannot close this report without expressing, in some slight degree, my appreciation of the confidence you showed in entrusting me with the work, of the readiness with which you endorsed my plans, and of the kindly help and encouragement you were always so ready to give me in the preparations for the observations.

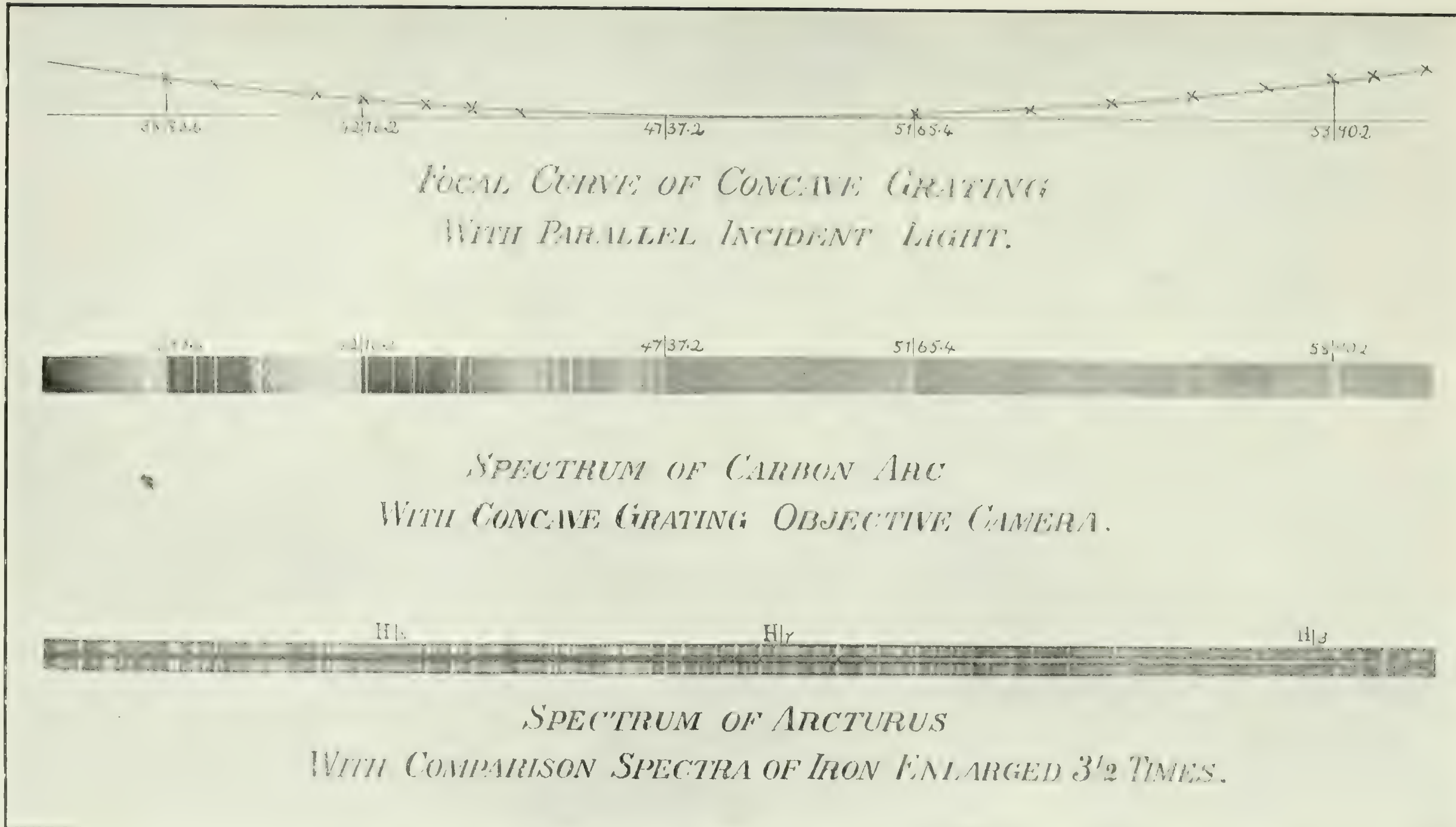

47|37.2
51|65.4
53|40.2
FOCAL CURVE OF CONCAVE GRATING
WITH PARALLEL INCIDENT LIGHT.
47|37.2
51|65.4
SPECTRUM OF CARBON ARC
WITH CONCAVE GRATING OBJECTIVE CAMERA.
Hγ
Hβ
SPECTRUM OF ARCTURUS
WITH COMPARISON SPECTRA OF IRON ENLARGED 3½ TIMES.

Fig. 1.

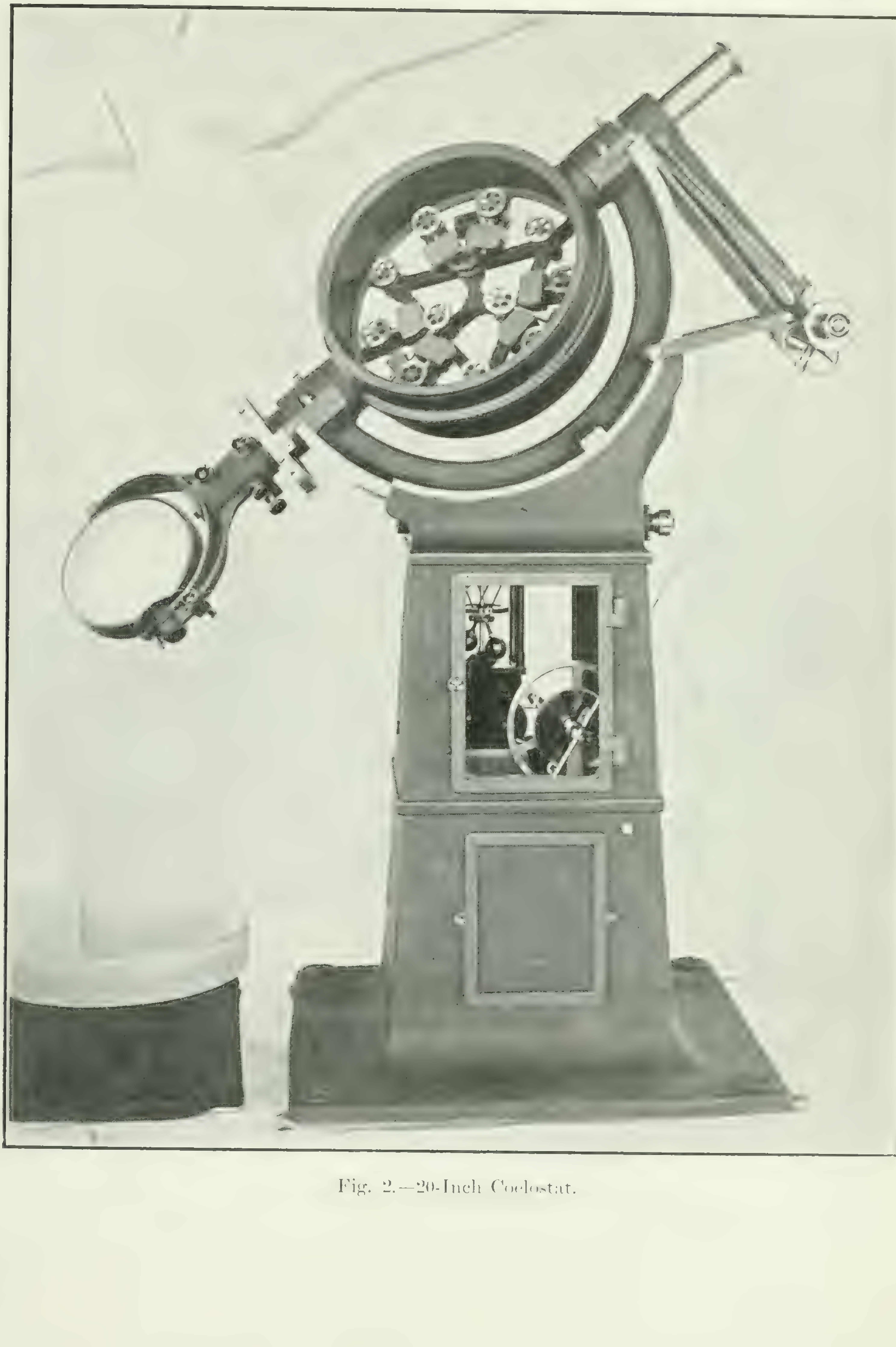


Fig. 2.—20-Inch Coelostat.

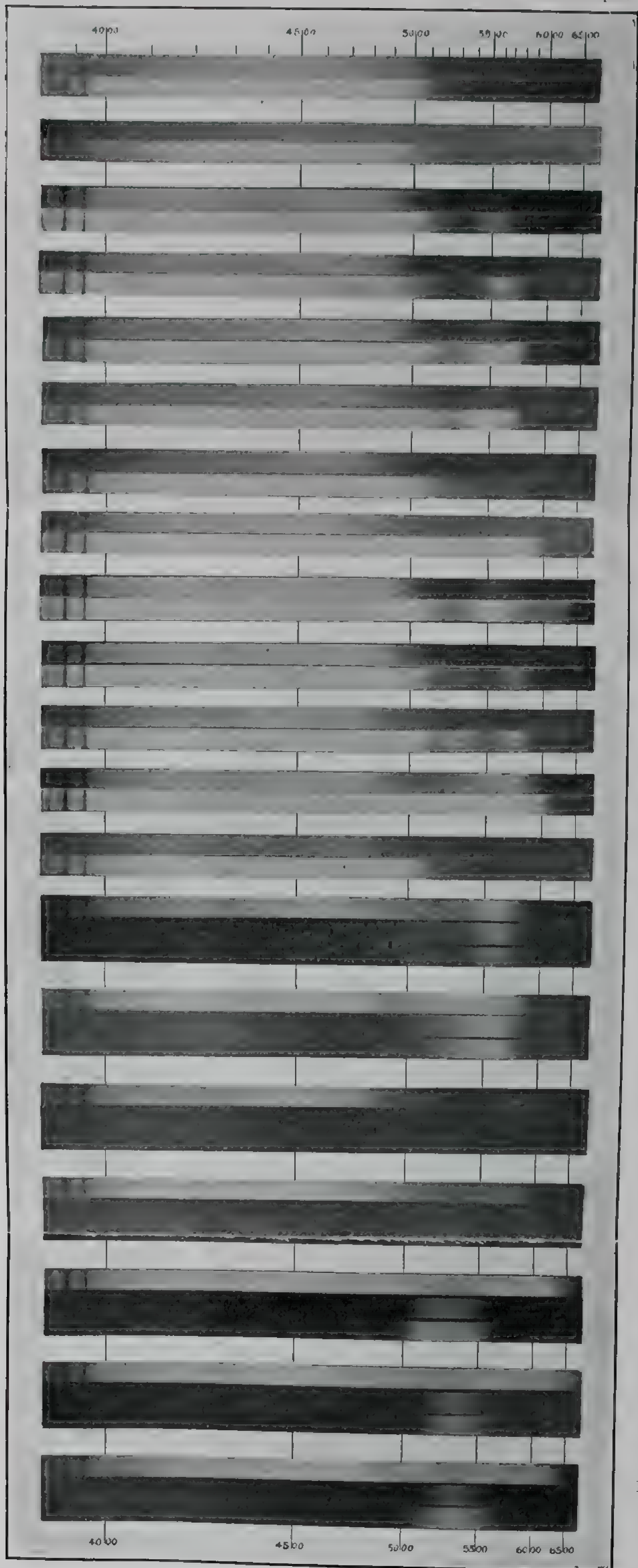


Fig. 3. Photographs of the Solar Spectrum on various Plates.

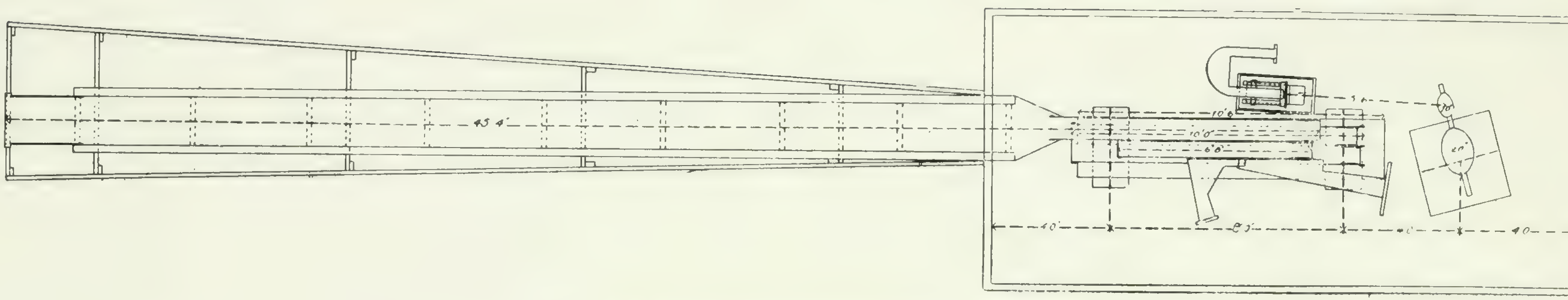


Fig. 4.—Plan of Camera Installation.

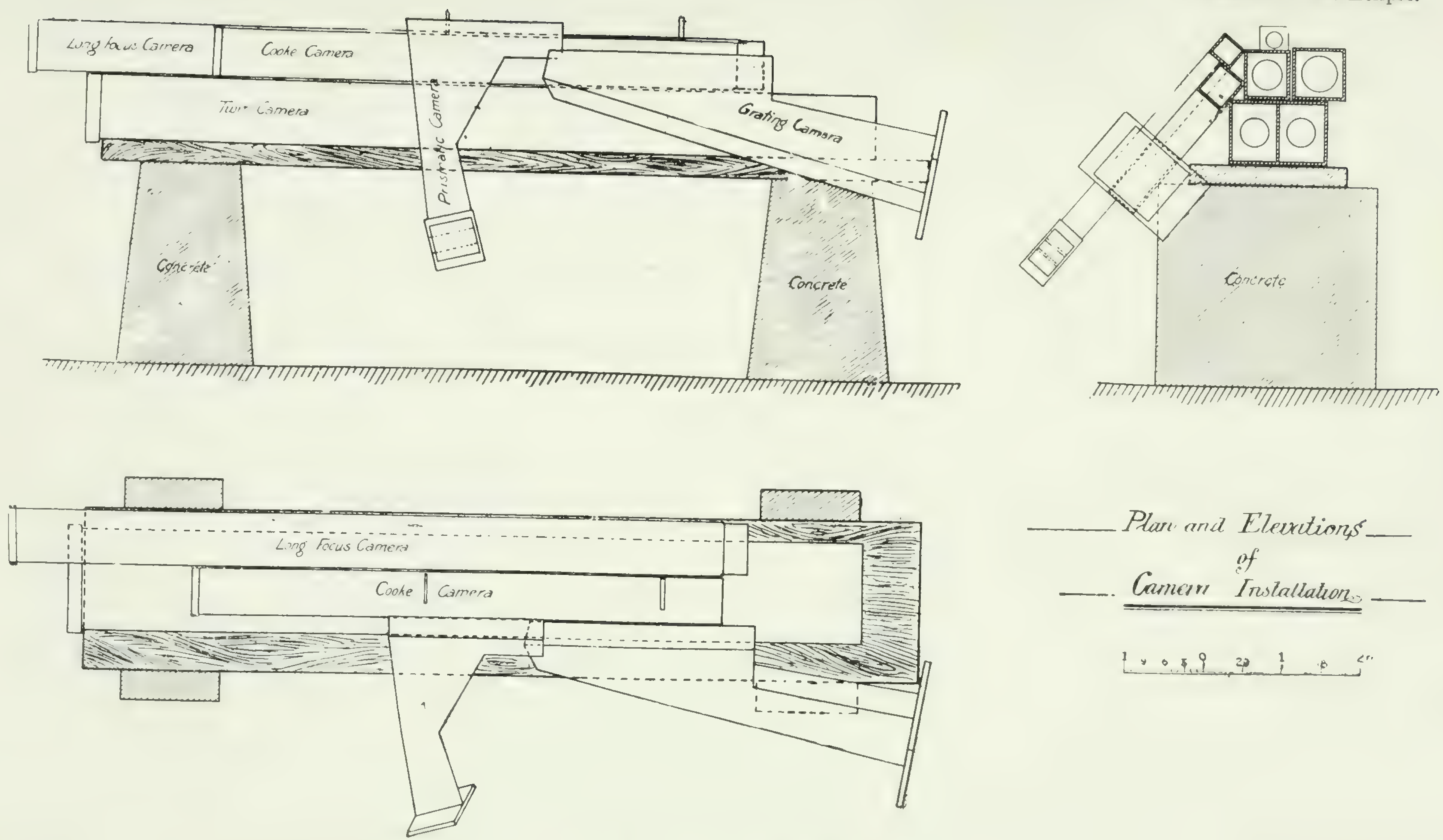


Fig. 5.—Camera Installation

Fig. 6.—Eclipse Camp at Northwest River.

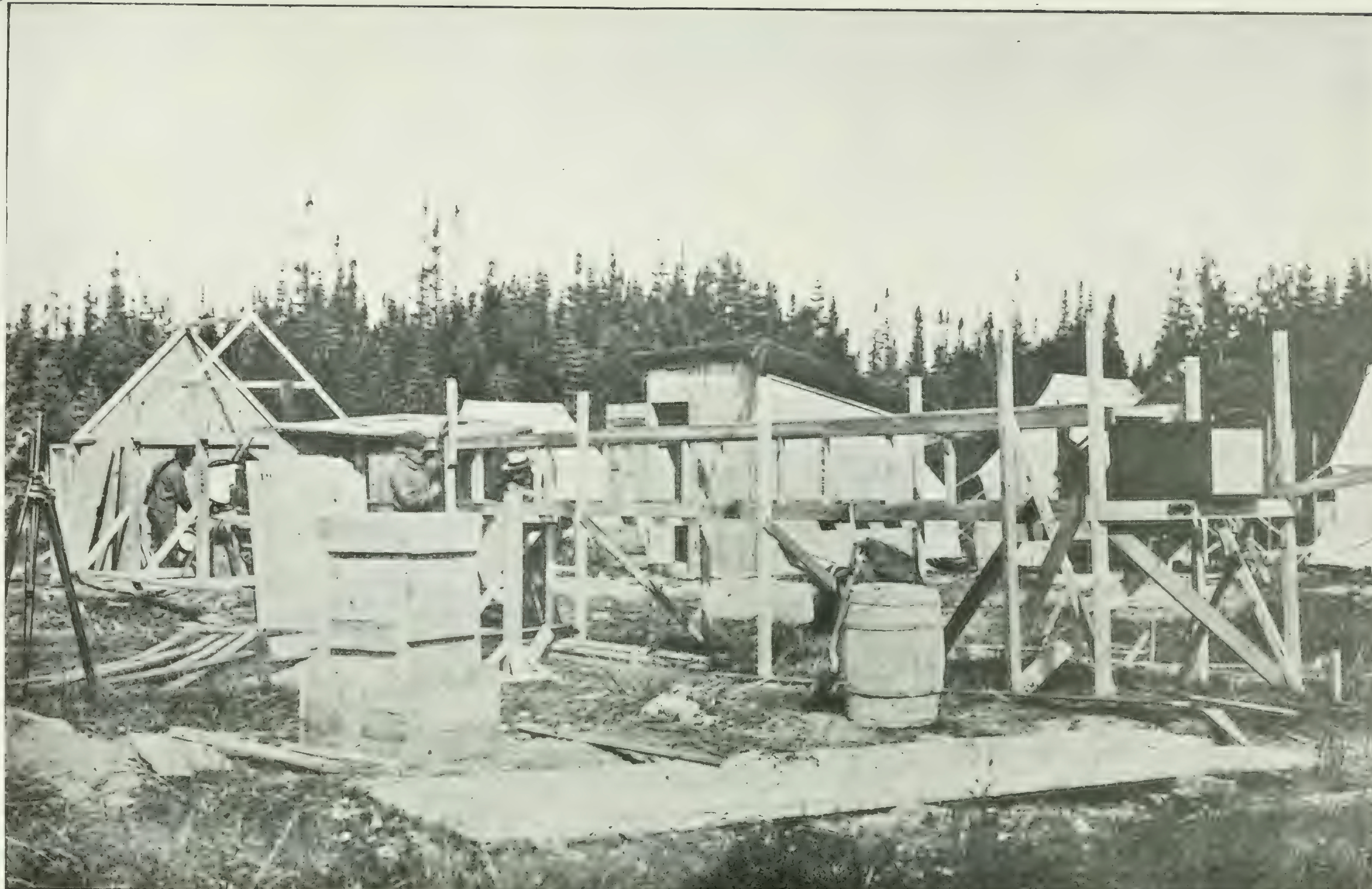


Fig. 7.—Construction of Long Focus Camera.

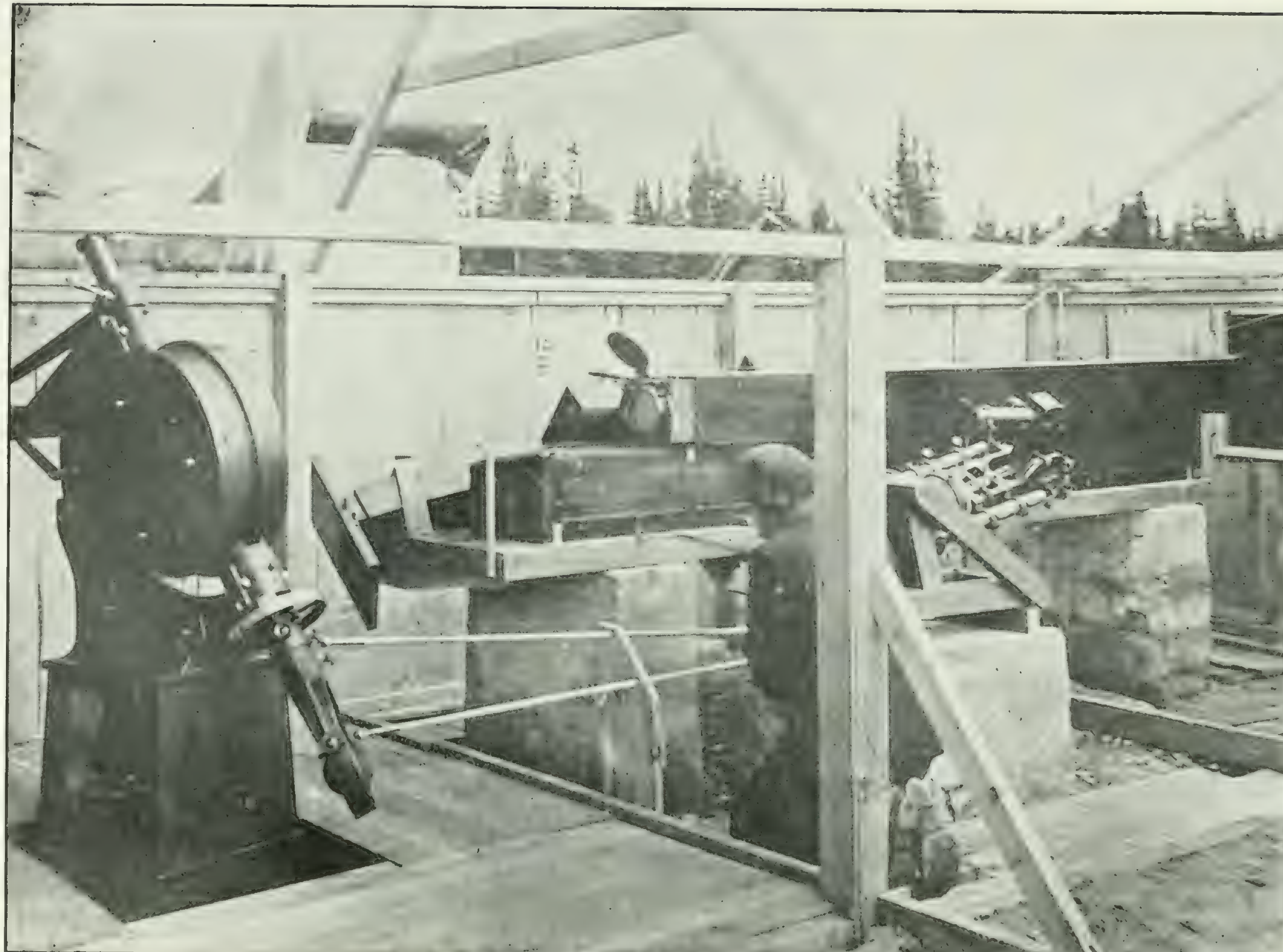


Fig 8.—View of Installation from South.

Fig. 9.—Rehearsal.

Fig. 10.—Rehearsal.

APPENDIX 6

REPORT OF THE CHIEF ASTRONOMER, 1905.

TIME SERVICE SYSTEM

BY

R. M. STEWART, M.A.

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ILLUSTRATIONS.

APPENDIX 6.

DESCRIPTION OF THE APPARATUS USED IN THE TIME SERVICE, BY R. M. STEWART, M.A.

W. F. King, Esq., B.A., LL.D., D.T.S., &c.,
Chief Astronomer,
Department of the Interior,
Ottawa.

Ottawa, Ont., October 21st, 1905.

Sir,—I have the honour to make the following report on the Time Service System connected with the observatory. Practically the whole equipment has been installed since the occupation of the new observatory building last May; consequently it is in several respects not yet perfected, as much of the apparatus requires experiment and considerable adjustment to get it into proper working condition.

The apparatus used in connection with the time service system may be divided into three main classes—a transit instrument, with its accessory apparatus, for obtaining the time by observation; a system of sidereal clocks for use in the observatory itself for the purposes of the time service and for observation; and a system of mean time clocks for use in the observatory and the government buildings. Each of these systems consists of two primary clocks mounted in the clock room, and any required number of secondary master-clocks and dials electrically controlled by one or other of these primaries. There are at present in use five secondary mean time master-clocks, synchronized by the mean time primary, one in the time room at the observatory, one in the parliament building, and one in each of the three departmental buildings. Each of these operates a number of electrically driven dials in the building where it is situated. One secondary sidereal master-clock is mounted in the time room, and is designed to operate dials wherever required in the building.

Clock Room.—The clock room is situated nearly in the centre of the basement of the observatory building, so that fluctuations in the outside temperature may be as little felt as possible; and, with the same end in view, it is separated from the rest of the basement by double doors which are kept always closed. A fairly constant temperature is maintained in the interior of the room by an electric heater connected with a thermostat set at the required degree of temperature. To equalize the temperature in all parts of the room an electric fan continually plays directly over the surface of the heater, keeping the air in constant circulation. A continuous record of the temperature is kept by a thermograph as a check on the temperature control, and so that if for any reason it should temporarily fail, allowance can be made for the circumstance in computing the clock errors.

The four primary clocks are mounted on cement piers. These piers are built entirely independent of one another, and of the floor and walls of the building; embedded in each one is a vertical marble slab, upon which the clock is securely bolted. They are disposed in pairs, one pair, consisting of a sidereal and a mean time clock, being placed at each end of the room. The clocks of each pair are so situated that the planes of oscillation of their pendulums are at right angles; in this way any mutual effect on their rates is obviated.

Howard Clock.—The Howard sidereal clock, made by the Howard Clock Company of Boston, which has been in use for some years, is shown in fig. 1. It has a mercurial pendulum and Denison's four-legged gravity escapement, and is equipped with an electric contact for chronograph work. The contact wheel is mounted on the same axis as the escapement wheel, and has 29 teeth corresponding to the even seconds, omitting the 58th. The contact itself consists of a platinum spring which bears against a point of the same metal; at every even beat (omitting the 58th) the spring is momentarily thrust aside by a tooth of the contact wheel, and the circuit broken. There is also a wheel with a single slot, turning once in five minutes, which operates a short-circuit at the 54th second, so that every fifth minute the breaks corresponding to both the 54th and 58th seconds are omitted. This circuit operates three relays in the time room, from which other circuits can be obtained as required. Previous to the completion of the observatory this clock was hung on a wall in the basement of the Supreme Court building, where, though its performance was very satisfactory, the stability of suspension and constant temperature requisite for extreme accuracy were not attainable. Even for some months after its removal to the observatory, the clock room, owing to pressure of other work, was not properly equipped; consequently the results of a thorough test of its performance under fair conditions are not yet available; the same applies also to the other clocks.

Riefler Sidereal Standard.—The Riefler sidereal standard (fig. 2), made by Clemens Riefler, Munich, has a compensated nickel-steel pendulum, free escapement, and electrical self-winding arrangement, and is inclosed in an air-tight glass cylinder. The pendulum rod is of nickel-steel, of composition 35·7 per cent nickel and 64·3 per cent steel, which has a coefficient of thermal expansion only about $\frac{1}{12}$ that of steel. Thus the compensation becomes a comparatively simple matter; the method is shown in fig. 3. The pendulum rod runs completely through the bob and has a regulating nut on the lower end. On this nut and surrounding the pendulum rod, rests a hollow cylinder of brass, surmounted again by one of steel; on the upper surface of this the pendulum bob is supported exactly at its centre. The relative lengths of brass and steel are adjusted so as to give the required amount of compensation.

On the pendulum-rod, toward its upper extremity, is a small shelf upon which small auxiliary weights may be placed for the final regulation of its rate before sealing up the cylinder; on the edge of this shelf is a scale to be viewed through a microscope, so that the amplitude of swing of the pendulum may be read from time to time. The glass cylinder is closed by an air-tight joint and partially exhausted, so that, provided the temperature is kept constant, the air pressure within the cylinder also remains constant. This obviates the change in clock rate due to change in barometric pressure, which affects a pendulum swinging in the open air sometimes as much as $\frac{1}{4}$ to $\frac{1}{2}$ second per day. The pressure inside the clock is kept at about 725^{mm} of mercury, so that it may be always lower than the outside barometric pressure. A thermometer and barometer are hung within the cylinder, to check the temperature and pressure from time to time.

The clock-weight consists merely of a lever attached by a ratchet to a wheel which engages the pinion of the escape-wheel; when the lever has dropped to a certain point it closes an electric circuit which raises it again to its highest position; this action recurs every 20 or 30 seconds. There is also on this clock an 'intermittent' seconds-contact through which runs a circuit operating two relays in the time room. From them may be obtained circuits for recording on the chronograph or for synchronizing secondary clocks. This contact, of which a diagram is shown in fig. 4, closes the electric circuit every alternate second; the even minute is recorded on the chronograph by the omission of one tooth on the contact wheel, so that the circuit remains closed from the 59th second to the 2nd second of the following minute. (Fig. 4 and fig. 7.)

Time Observations.—The Riefler sidereal is the clock which is used as the primary standard, the Howard and the Mean Time Primary being compared with it daily.

Its error, as also that of the Howard, is allowed to accumulate, and allowance made for it in computing the time. Observations for time are made as often as practicable—in summer practically every clear night, in winter at less frequent intervals, unless required for some particular purpose. On account of the type of electrical contact on the Riefler clock, which requires a double-record chronograph, it is more convenient to make the observations with the Howard. The error of the Riefler is obtained by comparing the two clocks on the chronograph both before and after the observations.

Time observations are made with a Cooke transit instrument mounted in the meridian. At present, pending the completion of the transit room, it is mounted in a small temporary shed east of the observatory. The object glass is of 3-inch clear aperture, with a focus of 35½ inches. In the focal plane is mounted a glass reticule upon which are ruled two horizontal lines and thirteen vertical lines. The vertical lines, or 'threads,' are separated into groups—a centre tally of five, a tally of three on each side of this, and two single threads one at each side; ordinarily only the middle eleven threads are used in observations. The equatorial interval between the threads of a tally is about 2·4 seconds of time, and that between the tallies about double this. The field of the instrument is illuminated by small electric lamps placed at the extremities of the axis, which is hollow; the light is reflected down along the tube by a diagonally placed mirror at the point of intersection of the axis and the line of sight; the intensity of the light is governed by a rheostat mounted conveniently on the side of the pier. A handle is mounted on the base by which the instrument can be lifted from the Y's and the axis reversed.

The chronograph used in the observations was made by Warner & Swasey. The cylinder is driven by clock-work so as to turn approximately once every minute. A small carriage carrying an electro-magnet with a pen attached to the armature is mounted alongside, and is moved longitudinally by an endless screw which turns at the same speed as the cylinder. The clock circuit goes through the coils of the electro-magnet, so that the pen traces a spiral line on the chronograph paper and records the beats of the clock. The circuit controlling the pen also passes through a key in the hand of the observer, who taps the key as the star passes over each successive thread in the field of the instrument, thus registering the transit on the chronograph. In addition, for convenience in picking out the transits on the sheet, he gives a continuous rattle on the key at the beginning and end of each observation. A chronograph sheet with a number of transits recorded is shown in fig. 6. During the time of observation, readings are also taken to determine the level error of the axis of the instrument.

A complete time determination for accurate purposes consists usually of observations of the transits of twelve stars, six in each position of the axis. The clock time of transits over the separate threads are scaled off the chronograph sheet, and the mean taken as the time of transit of that particular star over the meridian of the instrument. After the proper correction for level has been applied to each star, and the right ascensions of the stars found for that particular day, the results are computed by least squares for three unknowns, giving a determination of azimuth, collimation, and clock error for the mean time of the observations. The probable error of such a time determination is usually from one-hundredth to one-fiftieth of a second.

Comparison of the clocks is made on a chronograph which carries two magnets and two pens, one for each circuit. The record of a comparison is shown in fig. 7. The same clock is thrown on both sides of the chronograph for a portion of the time, so as to show the amount of the parallax of the pens, if any exists.

The apparatus so far described comprises the equipment for obtaining the time, and for preserving it as nearly as may be without error between successive observational determinations. The remainder of the equipment is applied to the purpose of furnishing exact time throughout the observatory itself, and to the public.

Of the two mean time clocks mounted in the clock room, one, also made by Riefler, is the main Mean Time Primary (fig. 8); the other, made by G. Borrel, of Paris, is intended to be used as an auxiliary primary and master-clock for the building (fig. 9).

Riefler Mean Time Primary.—The Riefler Mean Time Primary has a dead escapement, and a nickel-steel pendulum similar to that of the Sidereal Standard, but lighter and with a lens-shaped bob, to obviate air-resistance. The seconds-contact is an intermittent one, identical with that shown in fig. 4. It operates four relays in the time room, one for synchronizing the mean time master-clock, one to control the synchronization line running to the city, and two for recording on chronographs.

A mean time clock is of course required always to show the true time; hence an arrangement becomes necessary for correcting small outstanding errors from day to day. It consists of the two small auxiliary pendulums visible in fig. 8, mounted one on each side of the main pendulum. The one on the left has its centre of gravity slightly below its point of suspension, the one on the right slightly above. It follows that if the first of these is connected to the main pendulum, it will accelerate the clock, while the second will retard it. The method of controlling these auxiliary pendulums is shown in fig. 5. The electro-magnet *e*, is traversed by a circuit which runs to the switch-board in the time room: when the circuit is open, as is normally the case, the arm, *a*, is held clear of the shelf on the main pendulum rod, *p*, by the arm, *b*, connected to the armature, *c*; when the circuit is closed the armature is attracted, the arm, *a*, is released, and drops into the slot, *s*, thus throwing the auxiliary pendulum into connection with the main one; when the clock has been corrected to the required extent the circuit is opened and the arm, *a*, again lifted. The arrangement for the other auxiliary pendulum is similar. The rate of correction can be adjusted by moving the bobs of the auxiliary pendulums on their rods. That used is about six seconds per hour, so that a correction of a tenth of a second either way can be made by simply throwing the switch in the time room in the required direction for the space of a minute. The clock is compared with the sidereal standard every morning, and the proper correction made, if any is necessary.

Borrel Primary.—The Borrel clock is the one which was formerly used as the primary for the small experimental system installed in the Langevin block and the old offices of the Astronomical Branch on Wellington street. It has a pin wheel escapement and a wooden pendulum rod with a lead bob supported at the bottom, which gives a fair compensation for temperature. Its rate is considerably affected, however, by variations in the moisture of the atmosphere. The correction arrangement on it consists of a permanent magnet mounted longitudinally on the pendulum rod, immediately beneath which, and fixed to the clock case, is a solenoid entirely destitute of iron. If a current is passed in one direction through the solenoid the magnet is attracted and the clock accelerated, while a current in the opposite direction repels the magnet and retards the clock. The electrical contact operated by this clock consists of a spring attached to the pendulum rod close to its upper extremity, which makes contact with an adjustable screw every time the pendulum swings to the right.

This clock will be used as a reserve primary, to run the circuits ordinarily worked by the Riefler in case of stoppage of the latter through accident or for repairs, &c. It is also intended to fit it with two other contacts so that it may be used in addition as a reserve for the master-clock in the time room.

Time Room.—Fig. 10 shows a photograph of the switch-board and the two master-clocks in the time room. The clock on the right is the mean time master-clock, that on the left the sidereal. The mean time master-clock was made by Borrel, and is the one which was installed in 1902 in the offices of the Astronomical Branch on Wellington street as a part of the experimental system before referred to. It has a pin-wheel escapement and a pendulum with wooden rod and lead bob.

At the bottom of the clock-case and at one side there is a fixed vertical electro-magnet through which the intermittent current controlled by the primary clock flows; on the lower end of the pendulum rod, below the bob, there is a horizontal brass arm with an iron armature attached, which is attracted by the electro-magnet while the current flows; by means of the impulse thus administered every alternate second the pendulum is kept swinging in synchronism with that of the primary clock. It may be

remarked that the controlled pendulum lags in every case about half a second behind the controlling one; any error in indicated time is, of course, obviated by keeping the controlling clock that amount fast on true time. In the experimental system first installed the synchronization was effected in a different way; in place of the vertical electromagnet a horizontal solenoid was used, through which passed one end of a permanent bar magnet attached horizontally to the lower end of the pendulum rod; the other end of the magnet passed through a copper cylinder which served to damp the oscillations of the pendulum. This system, however, was found to be open to several objections, the most serious of which was that if from any cause (as was sometimes liable to happen when wires from one building to another were used) the synchronization current failed to flow, the synchronized clock must necessarily stop. Hence the present system, due to Riefler, was adopted, and has given complete satisfaction.

The electric contacts operated by the mean time master-clock are three in number; a diagram of the first is shown in fig. 12; the wheel, w, is mounted on the same axis as the escapement wheel; the arm, a, pivoted at p, rests ordinarily against the contact screw, b; at the 58th second it is lifted off b by the projecting jewel j on the contact wheel, and at the 59th pressed against the contact screw c, remaining there till the 60th second, when it drops back against b. Thus two circuits can be operated from this contact, one being closed from the 59th to the 60th second of every minute, the other continuously closed except from the 58th to the 60th second.

The first of these circuits operates a mercury contact relay in the relay cupboard at the base of the switchboard. This consists of a pair of vertical coils and an armature with a horizontal arm attached; at the end of the arm is an adjustable vertical screw, which dips into a mercury cup and completes the circuit when the relay is actuated. A relay of this type was found necessary where a fairly heavy current flows through the points, on account of the unavoidable sparking, which would oxidize the points of an ordinary relay and spoil the contact. Through this mercury connection flows the current which actuates the electric minute dials distributed throughout the building. These dials contain no clock movement of their own, but simply an electromagnet with the necessary mechanism for transforming the electro-magnetic impulses into the movement of the hands; as the impulse occurs only once a minute, the hands do not move gradually, but jump the space of one minute at a time, advancing always at the 60th second as indicated by the regulator. There are in the observatory twenty-six of these dials, which are divided into six circuits, all passing through the mercury contact referred to. In addition, the tower clock of the observatory is operated by the same circuit, but in a different way; on account of its size, the same method would be impracticable in its case. The hands are operated by a small motor which is cut in every minute by the electro-magnet connected with the minute-dial circuit; as soon as it has advanced the hands the space of one minute, it automatically cuts itself out, the time required for the movement of the hands being somewhat less than a second. The motor and auxiliary mechanism is situated just back of the dial, in an alcove off the equatorial room, and is shown in fig. 11. The dial is of sectional ground glass, of five feet diameter, and is equipped with lights for illumination. This is effected by a white back-board illuminated by eight 16 c.p. lamps arranged with reflectors in a circle around its edge between it and the dial.

The second contact on the mean time master-clock consists of two springs fixed one on each side of the pendulum rod close to its upper extremity, which make contact with adjustable screws fixed to the case as the pendulum swings to either side; this contact is intended for driving seconds-dials wherever required throughout the building, but is at present not in operation.

The remaining contact is operated by a wheel with a single tooth, which revolves once every hour; at about 30 seconds before the even hour it presses a spring against an adjustable screw, closing a circuit; at about thirty seconds after the hour the spring is released and the circuit opened. This circuit operates a relay which will be used in connection with dropping the time-ball on Parliament Hill; the arrangements for this have been completed and the wires installed, awaiting only the final connections.

The method of operating this circuit is shown diagrammatically in fig. 13. The relay A is the one operated by the hourly contact in the master-clock; the relay B, which when actuated closes two circuits and opens a third, is operated by the same circuit as the relay which controls the minute-dials, from the 59th to the 60th second of every minute; C is a neutrally adjusted polar relay. The time-ball circuit passes through the central points of B and the points of C. As will readily be seen from the diagram, when the relay A is not energized, the battery D will send a current through the coils of C for one second every minute, and the time-ball circuit will remain open through the points of C. When A is energized at 30 seconds before the even hour, the battery E is thrown on the coils of C, the circuit being completed at the 59th second through the left-hand points of B in the reverse direction to the former one, thus closing the time-ball circuit through the points of C. Finally when at the 60th second the circuit is completed through the central points of B, the current flows and releases the ball at the other end of the line. The right-hand pair of points of the relay B is to be used for sending preliminary signals, the arrangements for which have not yet been completed. In connection with this it is the intention to install a return signal to announce at the observatory the descent of the time-ball.

The sidereal master-clock in the time room is a Riefler clock, with the same pendulum and escapement as the mean time primary. It is equipped with a synchronization magnet similar to that in the mean time master-clock, and is synchronized by the Riefler sidereal standard. The electric contact operated by it is a reversing one, similar to that shown in fig. 4, with the addition of another contact screw below the lever, and the difference that there is no tooth omitted on the contact wheel. The circuit controlled by it will be reversed every second, and can be used for driving seconds-dials wherever required.

The time room switch-board controls all the circuits connected with the time service. On the lower part of it is fixed a relay cupboard containing two shelves, with sliding glass doors; these relays are the ones which operate all the different circuits. Just above the relay cupboard is a row of eighteen jacks through which the different circuits pass; on pushing a plug connected with the ammeter into any one of these, the ammeter is cut in without breaking the circuit. The switches are so arranged that any combination of the primary clocks can be thrown on either one of the two chronographs mentioned above, for purposes of comparison. Provision is also made for a circuit for another chronograph when required, and for the circuits required for longitude work. When the new transit building has been completed, the chronographs will be set up in a small room adjoining the time room, and opening directly into the transit room; in the meantime the double chronograph is set up temporarily in the time room, and the other in the temporary transit shed.

Battery.—The battery power used for the time system is obtained from twenty-six storage cells situated in the battery room in the basement. The battery room switch-board is shown in fig. 16. Down the right hand side of the board are two rows of jacks; to one of these rows come wires from the storage cells, giving a potential of four volts between adjacent jacks; to the other row come the different circuits. The connections are made by plugs connected by insulated wires, as shown in the figure. In this way any required voltage can readily be applied to any given circuit. The cells are charged weekly by the motor-generator in the workshop.

Outside Service.—Running from the observatory to the city there are four insulated wires used by the time service, in addition to two bare telegraph wires. Of these one pair runs to the time-ball on Parliament Hill; the other pair divides into four branches carrying the synchronization current for the master-clocks in the four government buildings. In each building there is a switch room containing the master-clock, a switch-board and relay cupboard, a battery cupboard containing storage cells, and a small motor-generator set for charging the battery. As the equipments in the different buildings are nearly identical, it will be sufficient to describe one. The apparatus in the switch room in the Langevin block is shown in fig. 17. The master-

clock is a Borrel clock identical with the one in the time room at the observatory; the master-clocks in the other buildings, however, were made by Riefler. The local synchronization current is worked from a relay driven by one branch of the main synchronization line from the observatory. The battery consists of nine storage cells, giving a potential of about eighteen volts; these are charged weekly. The motor-generator set is a Holzer & Cabot machine of 85 watts capacity. The motor is of the induction type with a self starting device, and runs on the ordinary electric light circuit; it is coupled directly to a compound wound generator giving 2·8 amperes at 30 volts. The charging circuit, which runs through a regulating rheostat on the switch-board, is usually turned on in the evening and off the next morning. In place of the ordinary automatic cut-out in the charging circuit, which, in case of stoppage of the motor for even a few seconds due to failure of current would cause the generator to run idle till morning, a special automatic low resistance relay is used. This consists, as shown in fig. 14, of a pair of vertical coils and an armature with a horizontal arm attached. In the unexcited state of the relay this arm makes contact with the spring *s*, completing the generator circuit through the coils of the relay and the resistance T. When the generator starts, as soon as the voltage becomes high enough to attract the armature, the arm *a*, is drawn down into the mercury cup *m*, making the lower contact just as it breaks the upper one, and throwing the battery into circuit through the rheostat R.

The minute dials are in this case divided into circuits of ten, which branch off wherever convenient from a pair of mains running to the switch-board; one of the dials is located in the switch-room to check the coincidence of the system with the master-clock. The dial circuit passes through the points of a mercury contact relay similar to the one in the time room at the observatory, and also through another relay which serves to open the corresponding branch of the main synchronization line, so as to furnish a signal at the observatory. The ammeter is a double-scale Weston, the upper scale reading to 2½ amperes, the lower to 250 milliamperes; the shunts required are operated by the switch directly underneath it. The current strengths are read in the same way as at the observatory, by several jacks and a plug attached to the ammeter.

Provision is made, in case of necessity, for working the minute-dial relays in as many of the other blocks as may be required, either from the Langevin block or from the parliament building, using the synchronization wires for the purpose. Thus in case of accident or repairs to any one of the master-clocks the dials dependent on it could still provisionally be kept going.

There are in operation at present 42 dials in the parliament building, 60 in the west block, 36 in the east block, and 48 in the Langevin block; in addition there are operated from the Langevin block two dials in the old offices of the Astronomical Branch on Wellington street, now occupied by the Schools Lands Branch of the department. These, with those at the observatory, make a total of 214 secondary dials now working, besides the tower clock at the observatory.

Check-dial.—As stated above, each of the four dial circuits is made to report itself to the observatory every minute by opening the synchronization line; a circuit has been so arranged at the observatory that these signals may operate a check-dial, shown in fig. 10, above the sidereal master-clock. A diagram of the connections employed for this purpose is shown in fig. 15. The relay A is traversed by the main synchronization current; when the synchronization line is closed the circuit through its points is open, and *vice versa*. B is a differentially wound, neutrally adjusted polar relay; through one pair of coils the main synchronization line passes in such a direction as to close the circuit through the points; through the other pair of coils, however, there flows in the opposite direction a stronger current, except from the 58th to the 60th second of every minute; this circuit is operated by one of the contacts described in the mean time master-clock. The circuit operating the check-dial passes in series through the points of these two relays. Evidently it will be held open at B up till the 58th second, and after this, since the relay is neutrally adjusted, it will remain open till closed by

the flowing of the synchronization current; this will next occur at the 59th second by the synchronizing clock, which, it will be remembered, corresponds to 58½ seconds by the master-clock, due to the lag of the latter. The circuit through B, then, is closed for the last 1½ seconds of every minute, provided a current flows through the synchronization line just previous to the 59th second by the master-clock. At the 59th second by the master-clock, each of the branches of the synchronization line is opened by the corresponding minute dial circuit, and, provided there is no short circuit on the main synchronization line, the circuit through the points of A is thereby closed, and the check dial is advanced one minute. In this way the check dial will keep true time only so long as there is no short circuit or break in the synchronization line, and so long as each of the minute dial circuits operates properly. A failure of any one of these conditions makes it lose time, and give warning to the official in charge.

In such a system of secondary electric clocks, on account of the multiplicity of delicate adjustments required for perfectly satisfactory working, it takes some time subsequent to installation before everything is in proper working condition; consequently a certain amount of trouble is to be expected for a time in any newly-equipped building. At the date of writing, however, most of these difficulties have been remedied, and the whole system is working fairly satisfactorily; as time progresses, it is hoped that the service will be still further perfected.

I have the honour to be, sir,

Your obedient servant,

R. M. STEWART.

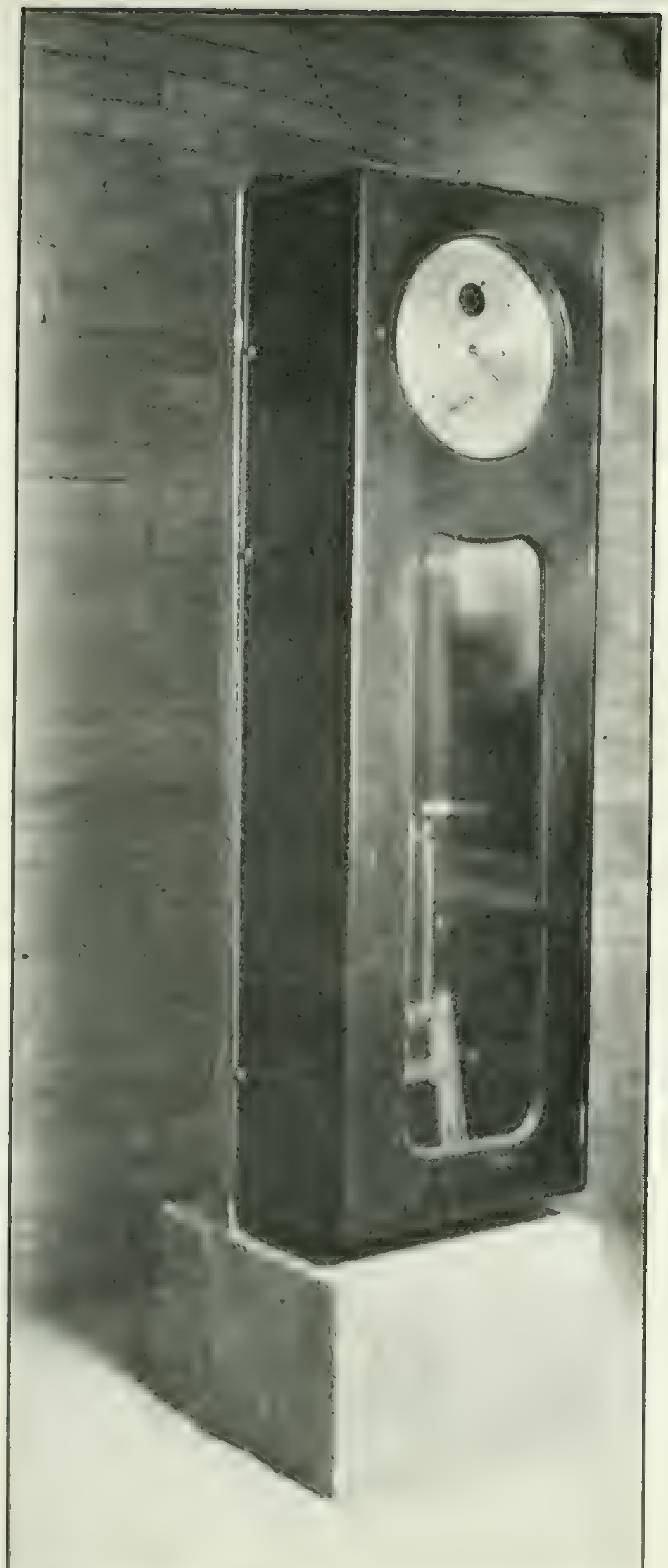

Fig. 1.– Howard Sidereal Clock.

Fig. 2.—Riefler Sidereal Standard.

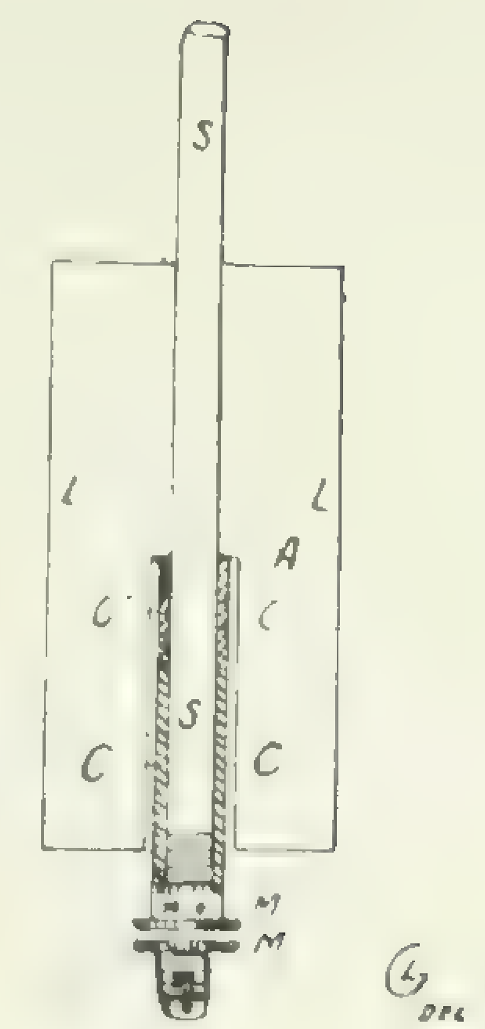

Fig. 3. Compensation of Riefler's Pendulum

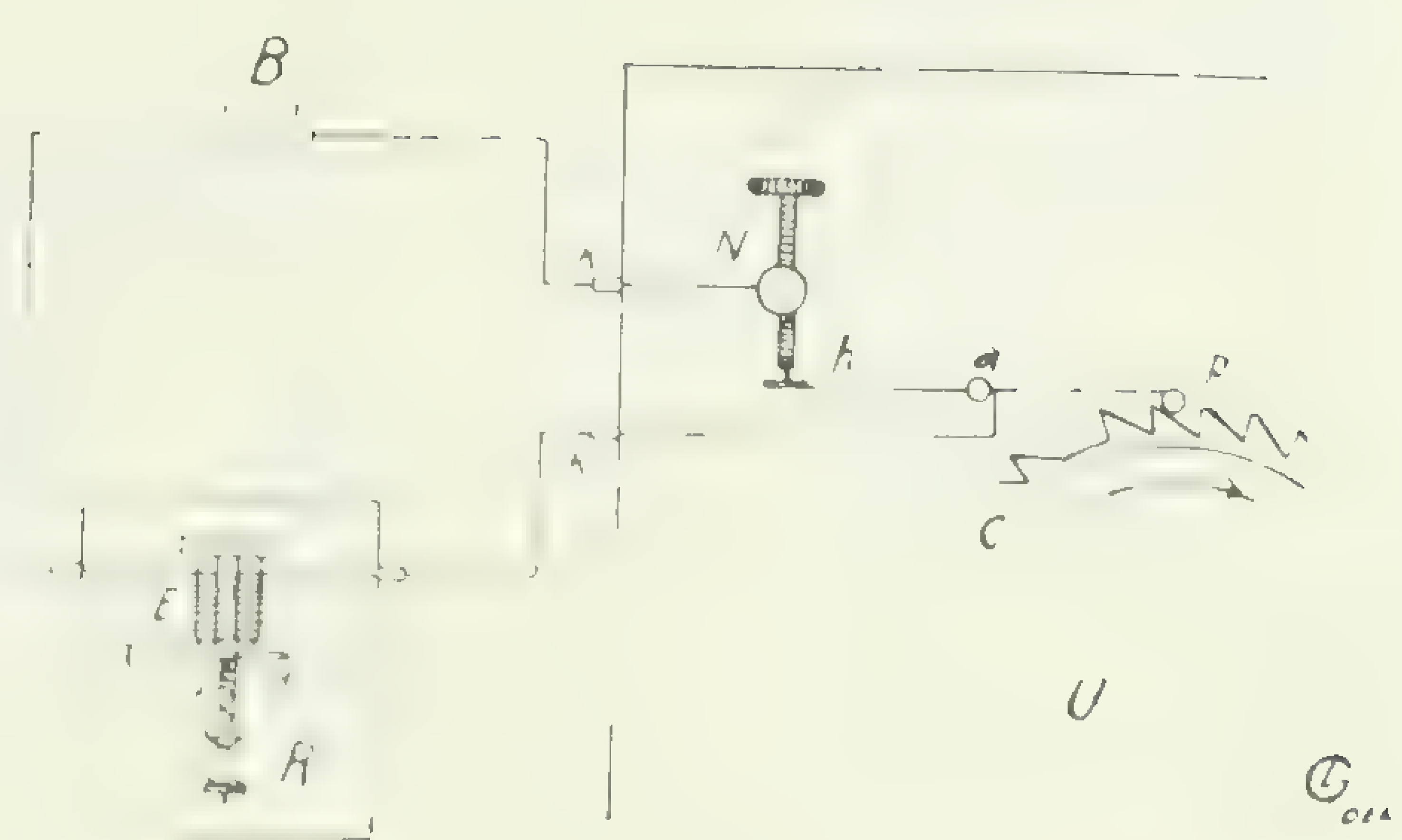

Fig. 4. Seconds-contact on Riefler Sidereal Standard.

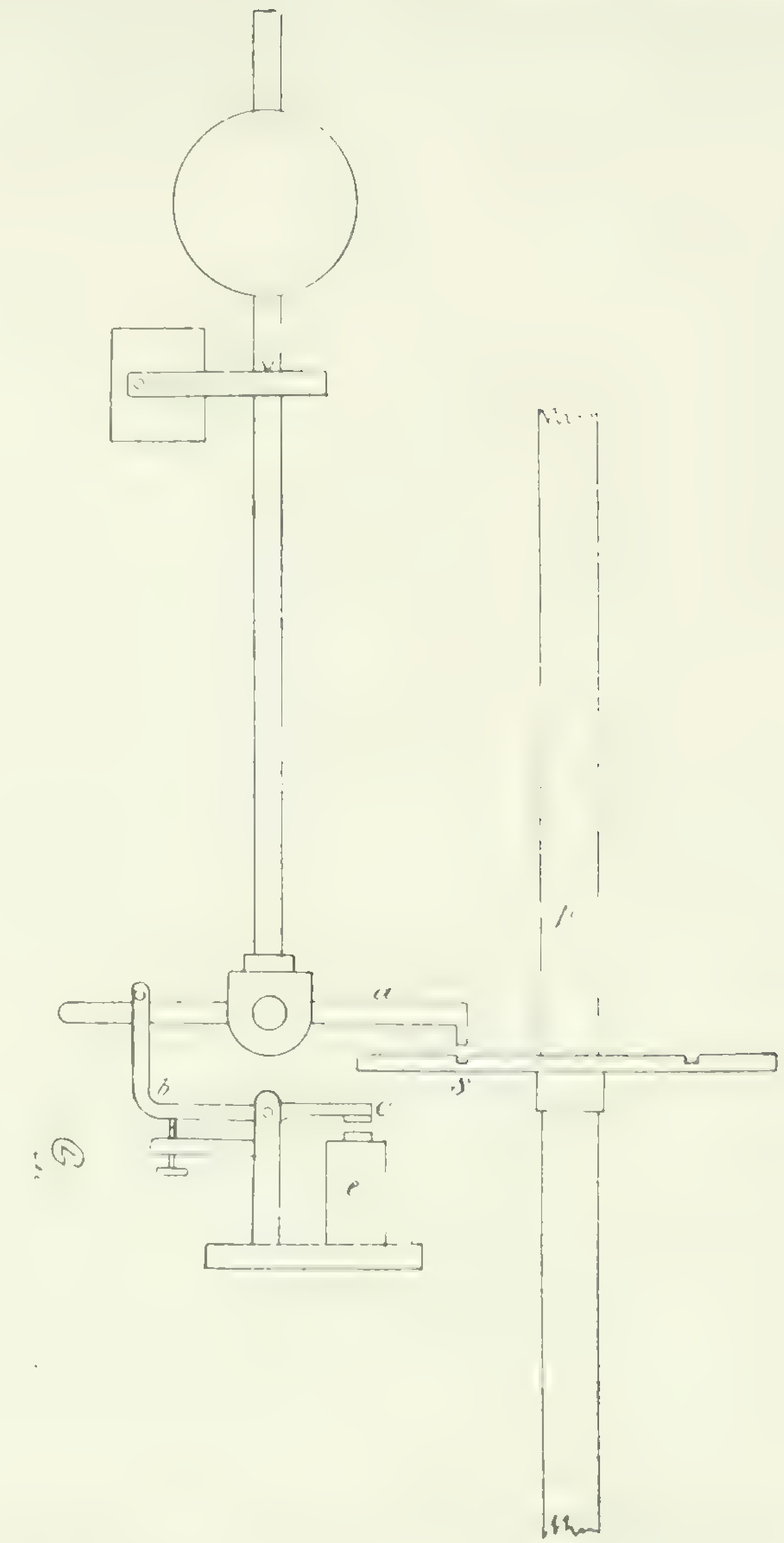

Fig. 5.—Method of Correcting Mean Time Primary.

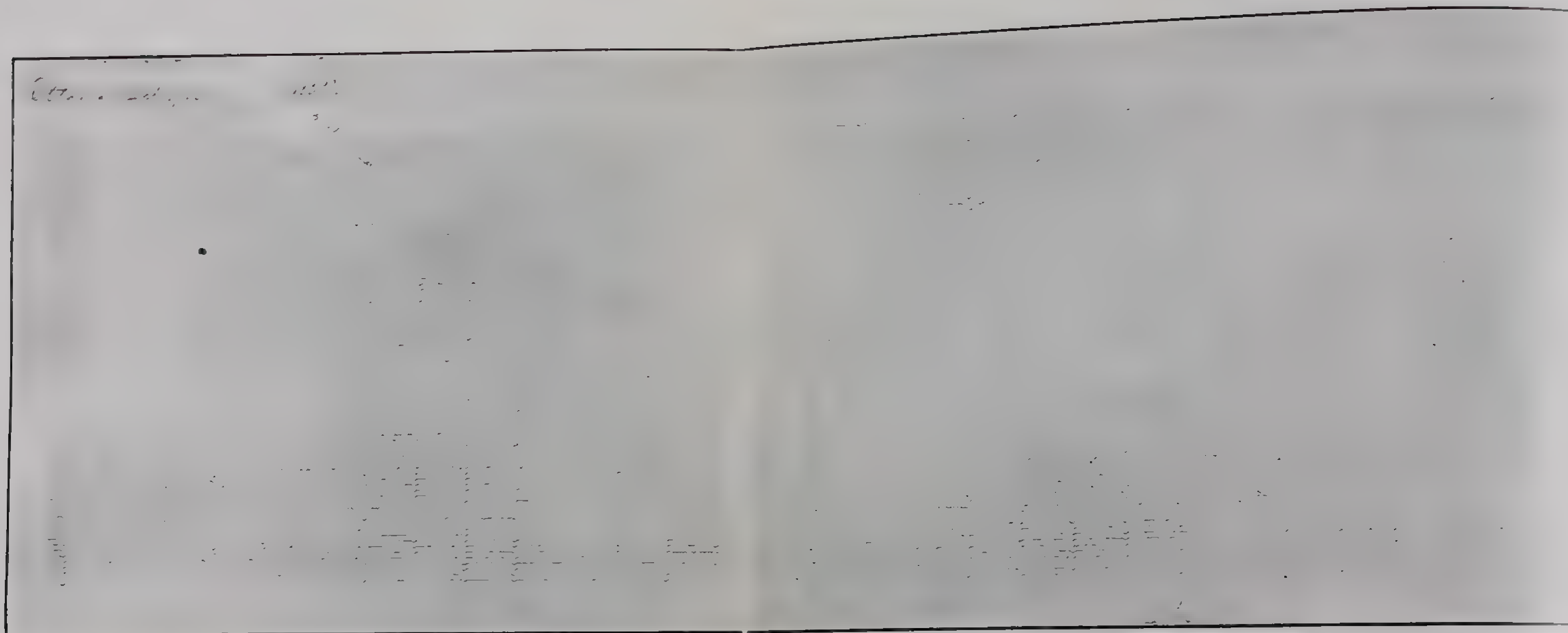

Fig. 6.—Chronograph Record of Time Observations.

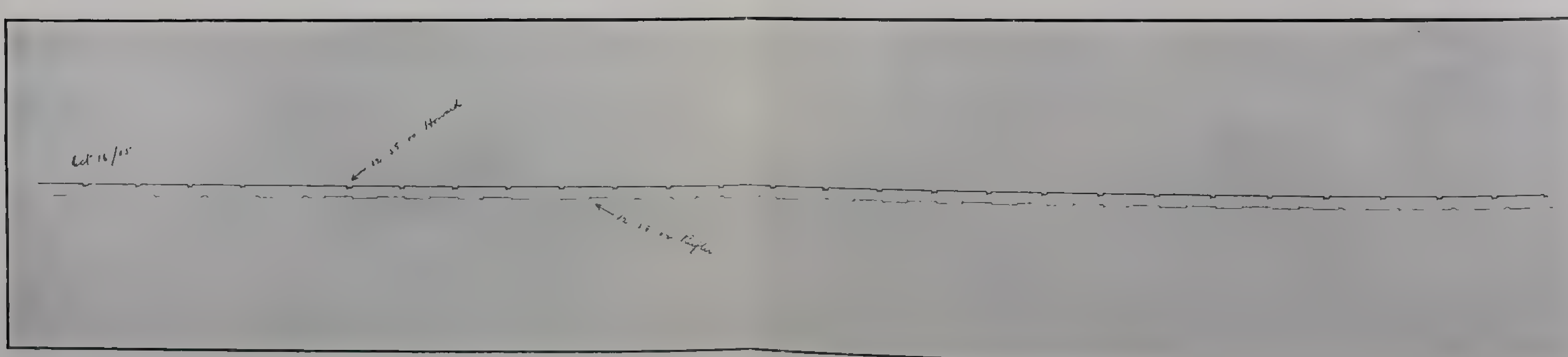

Fig. 7.—Chronograph Record of Clock Comparison.

Fig. 8.—Rietler Mean Time Primary.

Fig. 9.—Borrel Mean Time Clock.

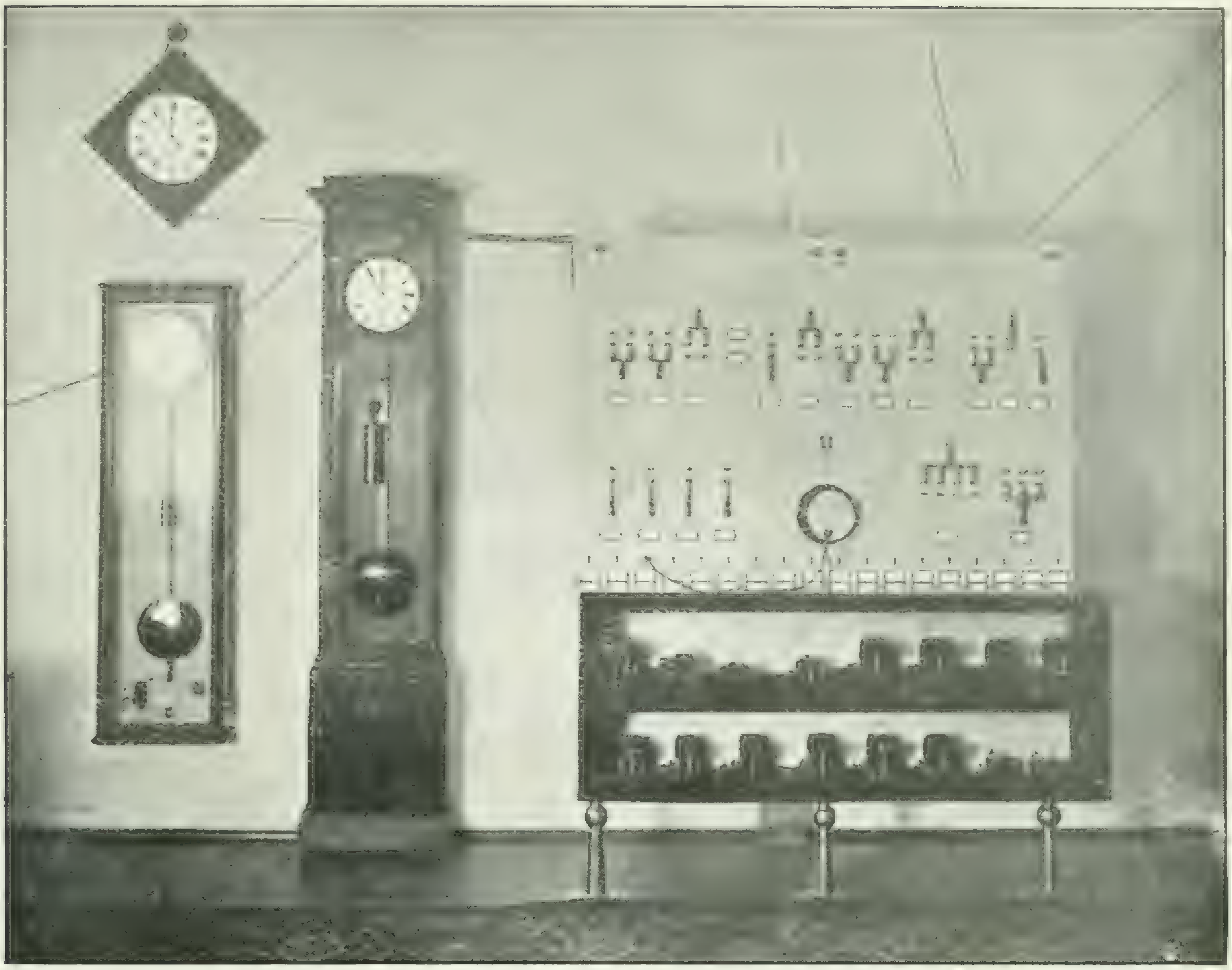

Fig. 10.—Time Room Installation.

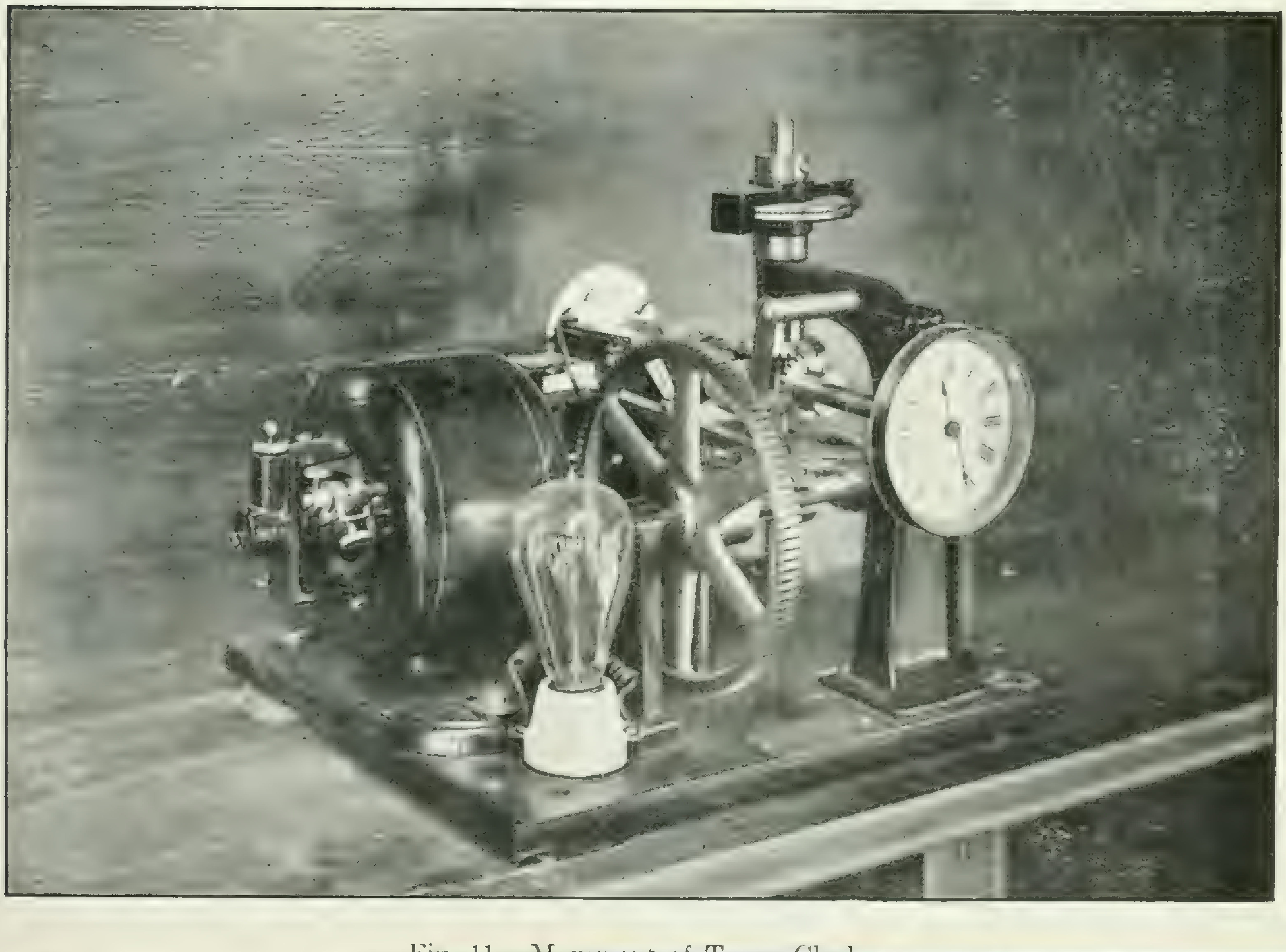

Fig. 11.—Movement of Tower Clock.

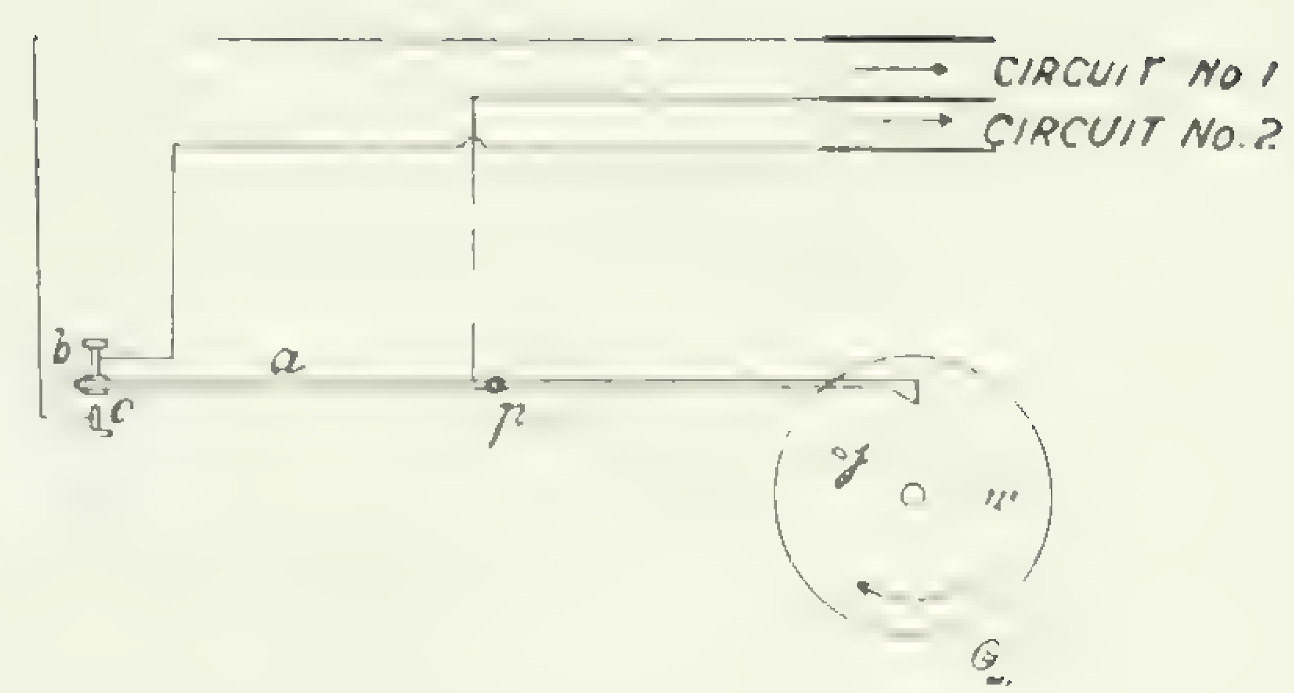

Fig. 12. Minute-contact on Master-Clock.

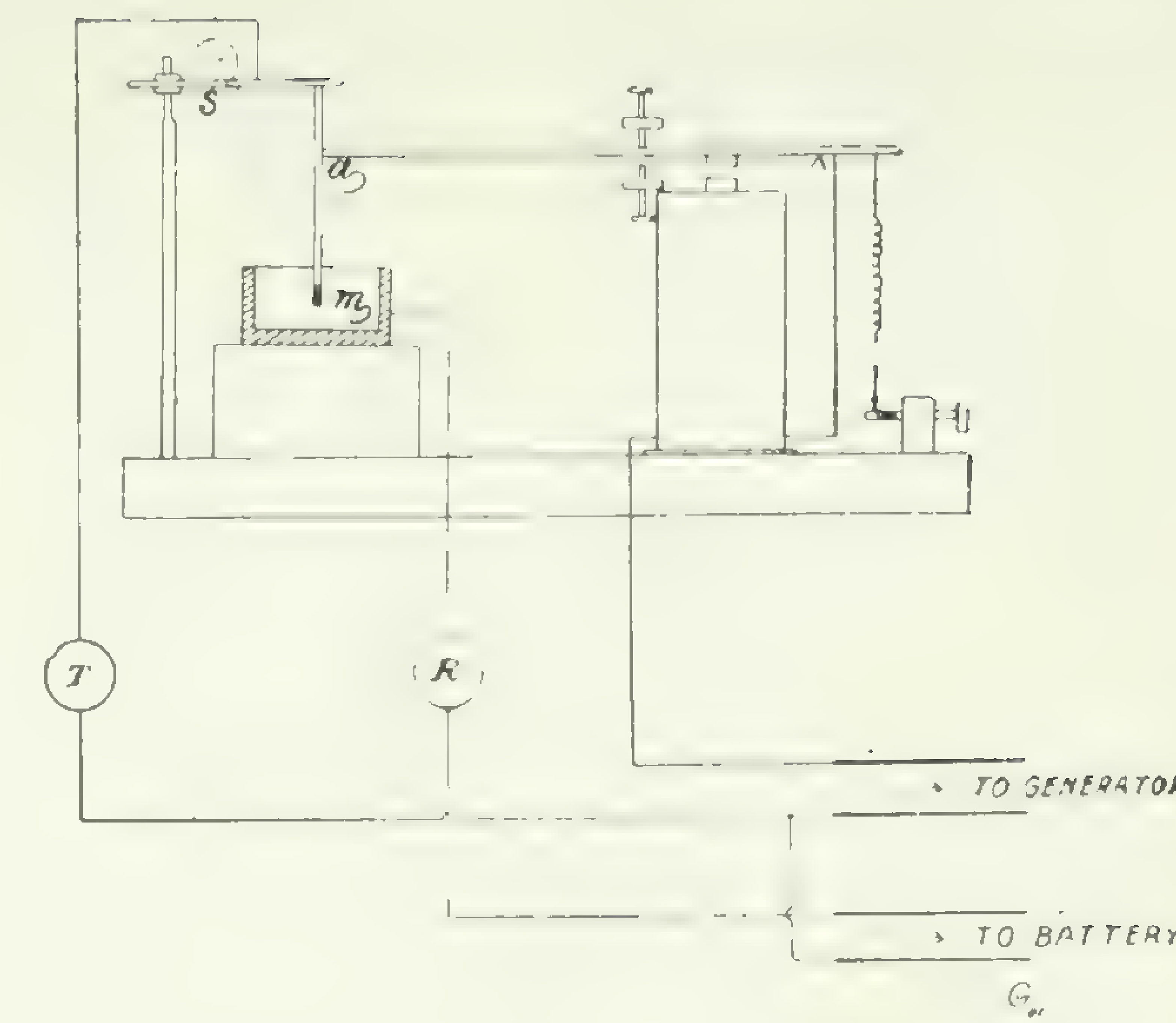

Fig. 14.—Cut-out Relay for Charging Circuit.

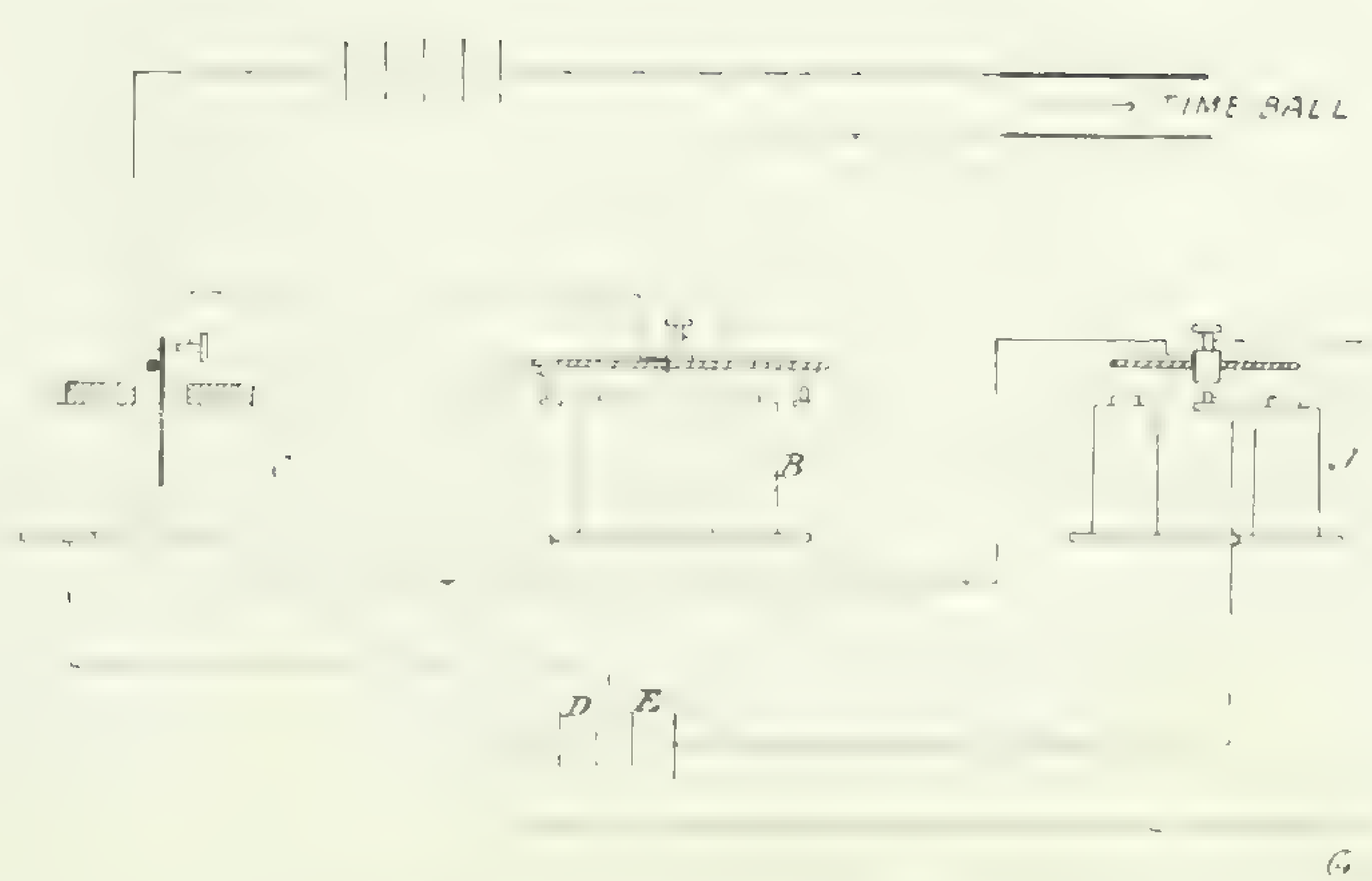

Fig. 13.—Time-ball Circuit.

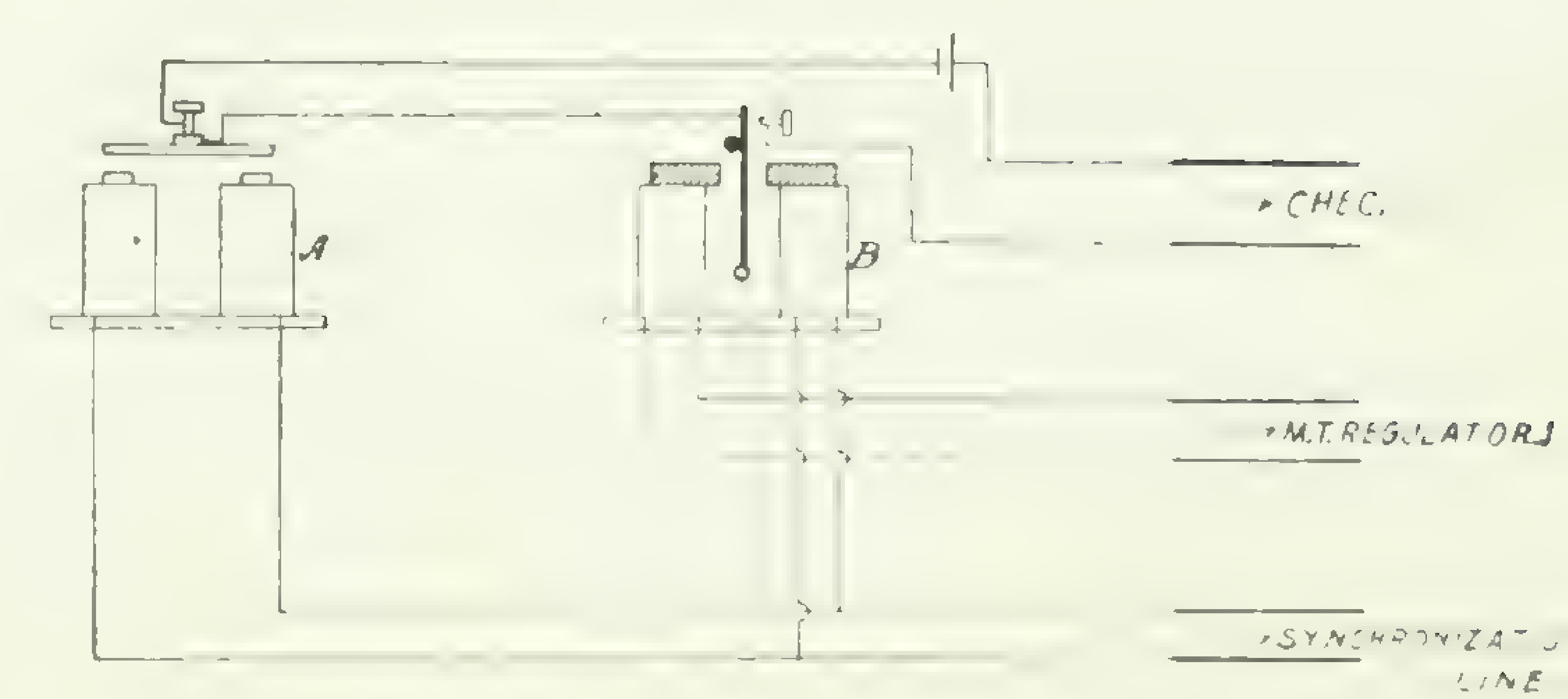

Fig. 15.—Check-dial Circuit.

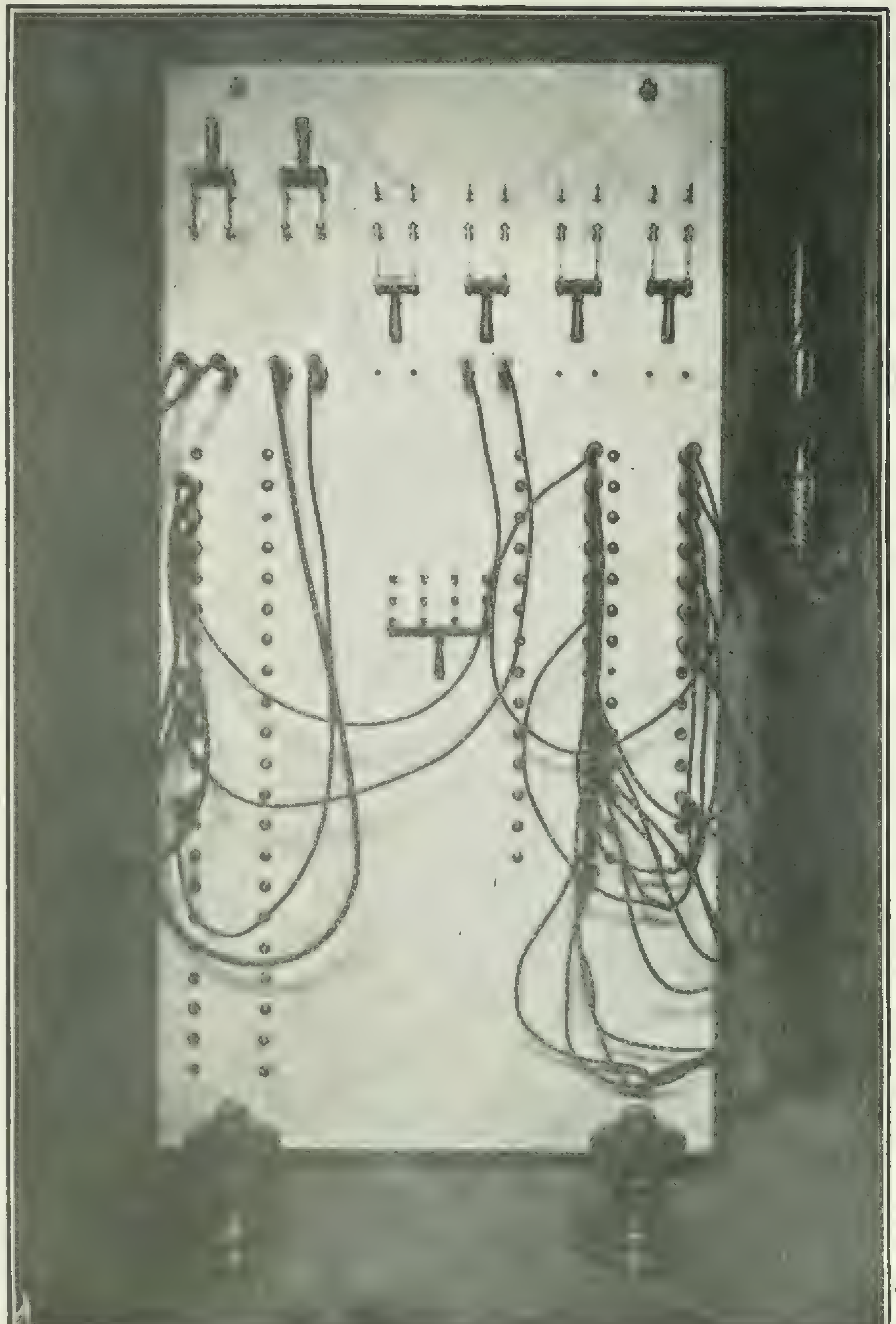

Fig. 16.—Battery Room Switch Board.

Fig. 17.—Langevin Block Installation.

APPENDIX 7

REPORT OF THE CHIEF ASTRONOMER, 1905.

TABULAR STATEMENT OF LONGITUDE OBSERVATIONS, 1885 TO 1904

BY

J. MACARA.

CONTENTS

APPENDIX 7.

TABULAR STATEMENT OF LONGITUDE OBSERVATIONS, 1885 to 1904.

OTTAWA, ONT., October 31, 1905.

W. F. KING, Esq., B.A., LL.D., D.T.S., &c.,
Chief Astronomer,
Department of the Interior,
Ottawa.

SIR,—I have the honour to submit herewith a summary of results, arranged in chronological order, for differences of telegraphic longitude between stations observed from 1885 to 1904.

In comparing the summary with the table of astronomical positions published in appendix I, part IX, of the annual report of 1904, a few slight discrepancies will be observed. It may be explained that this arises from the fact that the results for difference of longitude have been recomputed within the past year.

As a description of the stations was given in the above mentioned report of 1904, it has been considered unnecessary to repeat the information here.

A synopsis of the summary with the longitude of stations will be found on page 277.

I have the honour to be, sir,
Your obedient servant,

J. MACARA.

TABULAR STATEMENT OF LONGITUDE OBSERVATIONS, 1885 TO 1904.

DIFFERENCE OF LONGITUDE BETWEEN SEATTLE AND VICTORIA.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	
1885.	h. m. s.	h. m. s.	h. m. s.		h. m. s.		m. s.	m. s.	m. s.			s.
June 14....	1 23 17·24	1 23 17·06	8 25 42·47	....	7 06 32·03	....	4 06·80	4 06·62	4 06·71	....	....	·090
" 15....	1 23 19·14	1 23 19·03	8 25 46·65	....	7 06 34·36	....	4 06·85	4 06·74	4 06·795	....	....	·055

	m. s.
Mean	4 06·752
Personal equation................	·242
Δλ..........................	4 06·994

Observers, West, T. Drummond.
East, O. J. Klotz.

DIFFERENCE OF LONGITUDE BETWEEN KAMLOOPS AND PORT MOODY.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	
1885.	h. m. s.	h. m. s.	h. m. s.		h. m. s.		m. s.	m. s.	m. s.			
Aug. 11....	−1 21 44·58	1 21 44·65	+7 07 02·37	....	+8 38 52·23	....	10 05·28	10 05·21	10 05·245	....	....	....
" 12....	1 21 47·33	−1 21 47·40	+7 07 05·23	....	+8 38 58·05	....	10 05·49	10 05·42	10 05·455	....	....	....

	m. s.
Mean....	10 05·350
Personal equation.	—·242
Δλ....	10 05·108

Observers, West, O. J. Klotz.
East, T. Drummond.

DIFFERENCE OF LONGITUDE BETWEEN KAMLOOPS AND REVELSTOKE.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	v.	
1886.	h. m. s.	h. m. s.	h. m. s.	s.	h. m. s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
Aug. 15....	7 48 15·673	7 48 15·653	9 41 41·582	± ·024	2 01 55·457	± ·022	8 29·548	8 29·528	8 29·538	± ·033	·069	·010
" 15....	48 16·123	48 16·084	41 42·285	± ·023	01 55·463	± ·022	·301	·262	·281	± ·032	·188	·019
" 16..	52 10·689	52 10·658	45 39·554	± ·023	01 58·084	± ·017	·219	·188	·203	± ·029	·266	·015
" 17....	56 04·453	56 04·434	49 36·177	± ·017	02 01·388	± ·023	·664	·645	·654	± ·029	·185	·009
" 17....	56 05·070	56 05·051	49 36·804	± ·017	02 01·396	± ·023	·662	·643	·652	± ·029	·183	·009

	m. s.	s.
Weighted mean...............	8 29·469 ±	·014
Personal equation...............	— ·499 ±	·017
$\Delta\lambda$........................	8 28·970 ±	·022

Observers, West, W. Ogilvie.
East, O. J. Klotz.

DIFFERENCE OF LONGITUDE BETWEEN KAMLOOPS AND FIELD.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	
1886.	h. m. s.	h. m. s.	h. m. s.	s.	h. m. s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
Sept. 7...	9 17 34·666	9 17 34·619	11 12 12·630	± ·032	2 09 57·495	± ·066	15 19·530	15 19·483	15 19·507	± ·073	·055	·023
" 10...	29 10·556	29 10·494	23 53·954	± ·017	10 03·035	± ·019	·637	·575	·606	± ·025	·154	·031
" 10....	29 11·044	29 10·993	23 54·732	± ·017	03·040	± ·019	·352	·301	·327	± ·025	·125	·025
" 11....	33 03·758	33 03·708	27 50·417	± ·015	06·072	± ·020	·413	·363	·388	± ·025	·064	·025
" 11...	33 04·416	33 04·402	27 51·064	± ·015	06·079	± ·020	·431	·417	·424	± ·025	·028	·007
" 12....	36 55·596	36 55·583	31 44·154	± ·019	08·023	± ·024	·465	·452	·459	± ·031	·007	·007
" 12....	36 56·040	36 56·004	31 44·634	± ·018	08·029	± ·024	·435	·399	·417	± ·030	·035	·018
" 12....	36 56·606	36 56·574	31 45·065	± ·018	08·034	± ·024	·575	·543	·559	± ·030	·107	·016

	m.	s.		s.
Weighted mean..	15	19·452	±	·010
Personal equation.........		—·499	±	·017
$\triangle\lambda$.........................	15	18·953	±	·020

Observers, West, W. Ogilvie,
East, O. J. Klotz.

DIFFERENCE OF LONGITUDE BETWEEN CALGARY AND KAMLOOPS.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	
1886.	h. m. s.	h. m. s.	h. m. s.	s.	h. m. s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
Oct. 2 ...	10 51 53·520	10 54 53·460	12 50 36·538	± ·029	2 20 47·288	± ·017	25 04·270	25 04·210	25 04·240	± ·034	......	0·30
" 2 ...	54·340	54·274	37·650	± ·029	47·313	± ·017	04·003	03·937	03·970	± ·034	......	0·33
" 2	54·872	54·819	38·273	± ·029	47·324	± ·017	03·923	03·870	03·897	± ·034	......	0.27
								Weig't'd mean	25 04·036	± ·019	·122	
" 3 ...	10 58 48·144	10 58 48·095	12 54 34·526	± ·021	2 20 50·787	± ·020	25 04·405	25 04·356	25 04·380	± ·029	......	·025
" 3 ...	·546	·503	35·030	± ·021	·794	± ·020	·310	267	·289	± ·029	......	·022
								Weig't'd mean	25 04·334	± ·020	·176	
" 10 ...	11 25 48·106	11 25 48·030	13 21 59·215	± ·026	2 21 15·241	± ·013	25 04·132	25 04·056	25 04·094	± ·029	......	·038
" 10	48·616	48·539	·705	± ·026	·248	± ·013	·159	·082	·120	± ·029	......	·038
" 10	49·086	49·008	22 00·195	± ·026	·256	± ·013	·147	·069	108	± ·029	......	·039
" 10	49·988	49·922	01·005	± ·026	·267	± ·013	·250	·184	·217	± ·029	......	·033
								Weig't'd mean	25 04·135	± ·015	·023	

	m. s.	s.
Final weighted mean......	25 04·158	± ·010
Personal equation	− ·499	± ·017
ΔΛ..............	25 03·659	± ·020

Observers, West, W. Ogilvie,
East, O. J. Klotz.

DIFFERENCE OF LONGITUDE BETWEEN WINNIPEG AND KAMLOOPS.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	v.	
1886.	h. m. s.	h. m. s.	h. m. s.	s.	h. m. s.	s.	h. m. s.	h. m. s.	h. m. s.	s.	s.	s.
Nov. 9....	13 22 05·146	13 22 04·922	15 20 02·291	± ·014	3 30 44·888	± ·023	1 32 47·743	1 32 47·519	1 32 47·631	± ·027	......	·112
" 9....	05·592	05·363	02·782	± ·014	·901	± ·023	·714	·485	·599	± ·027	......	·115
" 9....	06·476	06·235	03·600	± ·014	·931	± ·023	·807	·566	·686	± ·027	......	·120
								Weig't'd mean	1 32 47·639	± ·016	·017	
" 10....	13 25 55·156	13 25 54·890	15 23 59·940	± ·020	3 30 52·561	± ·024	1 32 47·777	1 32 47·511	1 32 47·644	± ·031	......	·133
" 10....	56·124	55·873	24 00·934	± ·020	·578	± ·024	·768	·517	·642	± ·031	......	·126
" 10....	56·650	56·393	01·429	± ·020	·587	± ·024	·808	·551	·679	± ·031	......	·128
" 10....	57·111	56·864	01·924	± ·020	·595	± ·024	·785	·535	·660	± ·031	......	·125
								Weig't'd mean	1 32 47·656	± ·016	·000	
" 12....	13 33 37·492	13 33 37·240	15 31 50·592	± ·020	3 31 00·880	± ·028	1 32 47·788	1 32 47·536	1 32 47·662	± ·034	......	·126
" 12....	38·002	37·743	51·081	± ·020	·900	± ·028	·821	·562	·692	± ·034	......	·130
								Weig't'd mean	1 32 47·677	± ·024	·021	
" 14....	13 41 18·350	13 41 18·064	15 39 43·600	± ·020	3 31 12·987	± ·015	1 32 47·737	1 32 47·451	1 32 47·594	± ·025	......	·143
" 14....	18·868	18·592	44·094	± ·020	13·000	± ·015	·774	·498	·636	± ·025	......	·138
" 14....	19·396	19·113	44·588	± ·020	13·013	± ·015	·821	·537	·679	± ·025	......	·142
" 14....	19·936	19·654	45·083	± ·020	13·025	± ·015	·878	·596	·737	± ·025	......	·141
								Weig't'd mean	1 32 47·662	± ·014	·006	

	h. m. s.	s.
Final weighted mean..................	1 32 47·656	± ·008
Personal equation..................	·499	± ·017
Δλ to old observatory, Winnipeg.....	1 32 47·157	± ·019
Δλ survey connection	2·242	
Δλ to new observatory, Winnipeg....	1 32 44·915	± ·019

Observers, West, W. Ogilvie,
East, O. J. Klotz.

DIFFERENCE OF LONGITUDE BETWEEN WAPELLA AND WINNIPEG.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	
1887.	h. m. s.	h. m. s.	h. m. s.	s.	h. m. s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
June 30....	51·221	51·133	— 4 25 02·613	± ·023	— 4 06 32·444	± ·017	19 21·390	19 21·302	19 21·346	± ·028	·187	·044
July 1 ..	48·923	48·856	— 03·791	± ·025	— 31·010	± ·022	21·704	21·637	·671	± ·033	·138	·034
" 2...	45·416	45·336	— 05·621	± ·009	— 29·687	± ·027	21·350	21·270	·310	± ·028	·223	·040
" 3 ..	41·665	41·614	— 05·347	± ·009	— 28·391	± ·032	21·621	21·570	·595	± ·033	·062	·026
" 5...	33·593	33·540	— 14·328	± ·016	— 26·198	± ·019	21·723	21·670	·696	± ·024	·163	·027

	m. s.	s.
Weighted mean....	19 21·533	± ·012
Personal equation....	— ·028	± ·018
λ to old observatory, Winnipeg	19 21·505	± ·021
λ survey connection....	2·242	
∴ λ to new observatory, Winnipeg....	19 19·263	± ·021

Observers, West, O. J. Klotz,
East, W. F. King.

DIFFERENCE OF LONGITUDE BETWEEN PORT ARTHUR AND WINNIPEG.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	
1887.	m. s.	m. s.	h. m. s.	s.	h. m. s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
July 22....	13·391	13·307	− 4 06 01·887	± ·029	− 3 34 35·275	± ·012	31 40·003	31 39·919	31 39·960	± ·031	·131	·042
" 26...	28·392	28·310	− 05 54·583	± ·033	− 34 42 681	± ·020	40·294	40·212	40·253	± ·038	·162	·041
" 27 ..	31·494	31·428	− 05 52·479	± ·033	− 34 43·793	± ·019	40·180	40·114	40 147	± ·038	·056	·033
" 30 ..	44·886	44·816	− 05 45·904	± ·033	− 34 50·602	± ·012	40·188	40·118	40 153	± ·035	·062	·035
Aug. 29 ...	23·499	23·432	− 04 49·932	± ·030	− 36 33·388	± ·022	40·043	39·976	40·009	± ·035	·082	·034

Observers—West, W. F. King.
East, O. J. Klotz.

	m.	s.		s.
Weighted mean	31	40·091	±	·025
Personal equation		·101	±	·017
∴ Δλ to old observatory, Winnipeg	31	40·192	±	·031
Δλ survey connection		+ 2·242		
∴ Δλ to new observatory, Winnipeg.	31	42·434	±	·031

DIFFERENCE OF LONGITUDE BETWEEN WINNIPEG AND KALMAR.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	
1887.	m. s.	m. s.	h. m. s.	s.	h. m. s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
Sept. 30	5 49·325	5 49·301	4 03 22·686	± ·025	4 00 31·507	± ·019	8 40·504	8 40·480	8 40·492	± ·031	·040	·012
Oct. 3	6 07 038	6 07·012	03 08·932	± ·019	35·169	± ·015	40·501	40·475	·488	± ·024	·044	·013
" 4	6 16 950	6 16·926	02 59·230	± ·007	35·414	± ·023	40·766	40·742	·754	± ·024	·222	·012
" 5	6 22·118	6 22·096	02 52·816	± ·021	34·129	± ·010	40·505	40·483	·494	± ·023	·038	·011

Observers West, W. F. King.
East, O. J. Klotz.

	m. s.		s.
Weighted mean	8 40·532	±	·013
Personal equation	·056	±	·017
$\Delta\lambda$ to old observatory, Winnipeg	8 40·476	±	·021
$\Delta\lambda$ survey connection	+ 2·242		
$\therefore \Delta\lambda$ to new observatory, Winnipeg	8 42·718	±	·021

DIFFERENCE OF LONGITUDE BETWEEN EDMONTON AND WINNIPEG.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals	Mean.	Probable Error.	r.	
1888.	m. s.	m. s.	h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	h. m. s.	s.	s.	s.
July 8....	0 59·690	0 59·603	— 1 04 08·795	± ·014	19·868	± ·007	1 05 28·353	1 05 28·266	1 05 28·310	± ·016	·009	·043
" 9...	1 01·025	1 00·902	— 1 04 07.182	± ·018	20·231	± ·024	28·438	28·315	28·376	± ·030	·057	·061
" 10....	1 01·004	1 00·916	— 1 04 06·736	± ·033	20·565	± ·015	28·305	28·219	28·262	± ·036	·057	·044
" 11....	1 02·222	1 02·106	— 1 04 05.124	± ·013	21·079	± ·015	28·425	28·309	28·367	± ·020	·048	·057
" 16 ...	1 13·873	1 13·783	— 1 03 53·337	± ·013	21·225	± ·009	28·435	28·345	28·390	± ·016	·071	·045
" 18 ...	1 17·873	1 17·787	— 1 03 50·447	± ·012	19·976	± ·011	28·296	28·210	28·253	± ·016	·066	·043
" 19....	1 17·889	1 19·797	— 1 03 48·983	± ·036	19·543	± ·009	28·415	28·323	28·369	± ·037	·050	·046
" 20 ...	1 22·136	1 22·000	— 1 03 48·684	± ·012	19·493	± ·017	28·313	28·177	28·245	± ·021	·074	·063

Observers—West, O. J. KLOTZ.
East, W. F. KING.

	h. m. s.	s.
Weighted mean	1 05 28·319	± ·007
Personal equation	·354	± ·013
$\Delta\lambda$	1 05 27·965	± ·015

DIFFERENCE OF LONGITUDE BETWEEN WINNIPEG AND ONION LAKE.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	
1888.	m. s.	m. s.	m. s.	s.	s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
Sept. 1 ..	4 25·628	4 25·563	— 47 13·193	± ·014	—11·393	± ·015	51 27·428	51 27·365	51 27·396	± ·020	·099	·032
" 3 ...	....	3 52·774	— 47 06·134	± ·013	+28·273	± ·012	....	....	27·181	± ·017	·106	
" 4	3 57·181	3 57·076	— 47 02·780	± ·018	+27·327	± ·013	27·288	27·183	27·235	± ·022	·052	·053
" 6 ...	4 04·201	4 04·103	— 46 57·529	± ·011	+25·626	± ·009	27·356	27·258	27·307	± ·014	·020	·049
" 7	4 07·071	4 06·965	— 46 54·521	± ·023	+25·792	± ·017	27·384	27·278	27·331	± ·028	·044	·053
" 8 ...	4 13·612	4 13·550	— 46 50·587	± ·020	+23·162	± ·013	27·361	27·301	27·330	± ·024	·043	·031

Observers—West, O. J. Klotz.
East, W. F. King.

	m.	s.		s.
Weighted mean	51	27·287	±	·008
Personal equation		·454	±	·010
$\Delta\lambda$	51	26·833	±	·013

DIFFERENCE OF LONGITUDE BETWEEN MATTAWA AND OTTAWA.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	
1890.	m. s.	m. s.	s.	s.	s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
Sept. 14 ...	12 17·173	12 17·121	20·967	± ·009	3·042	± ·014	11 59·248	11 59·196	11 59·222	± ·016	....	·026
" 16....	22·109	22·074	26·247	± ·011	3·278	± ·006	59·140	59·105	59·122	± ·013	.....	·018

Observers—West, E. Deville.
East, W. F. King.

	m. s.		s.
Weighted mean	11 59·172	±	·010
Personal equation	— ·152	±	·019
$\Delta\lambda$	11 59·020	±	·022

DIFFERENCE OF LONGITUDE BETWEEN MONTREAL AND OTTAWA.

Date.	Difference of Chronograph. Western Signals.	Eastern Signals.	Station	Clock Correction. Before Signals. At T_1	ΔT	After Signals. At T_2	ΔT	At Signals. At T	ΔT	ϵ	Difference of Longitude. Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	Time of Transmission.
1896.	m. s.	m. s.		h. m.	s.	h. m.	s.	h. m.	s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
June 3.	9 03·480	9 03·457	W.	17 13	− 3·206	16 00	− 3·201	15 13	− 3·207	± ·018						
			E...	13 30	− 35·165	17 45	− 35·609	15 22	− 35·360	± ·010	8 31·327	8 31·304	8 31·315	± ·021	·100	·011
" 4.	06·489	06·464	W.	17 13	− 3·206	16 00	− 3·201	15 13	− 3·201	± ·024						
			E...	13 30	− 37·955	16 50	− 38·391	15 22	− 38·199	± ·010	·501	·476	·488	± ·026	·027	·012
" 5.	04·431	09·417	W.	16 00	− 3·201	16 00	− 3·082	15 28	− 3·085	± ·017						
			E...	13 30	− 40·816	......	......	15 37	− 41·064	± ·011	·452	·438	·445	± ·020	·070	·007
" 10.	19·149	19·128	W.	......	......	16 00	− 4·367	15 34	− 4·361	± ·014						
			E...	......	......	16 10	− 52·152	15 43	− 52·089	± ·021	·421	·400	·411	± ·025	·004	·010
" 12.	22·192	22·153	W.	14 00	− 4·219	16 00	− 4·207	15 39	− 4·209	± ·018						
			E..	13 30	− 54·808	17 20	− 55·043	15 49	− 54·941	± ·014	·460	·421	·441	± ·023	·026	·019

Observers, West, C. H. McLeod.
East, W. F. King.

Weighted mean .... m. 8 s. 31·415 s. ± ·011

Date.	Western Signals.	Eastern Signals.	Station	At T_1	ΔT	At T_2	ΔT	At T	ΔT	ϵ	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	Time of Transmission.
	m. s.	m. s.		h. m.	m. s.	h. m.	m. s.	h. m.	m. s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
June 26	9 50·501	9 50·463	W.	16 00	− 7·390	18 00	− 7·452	16 47	− 7·414	± ·010						
			E...	15 15	−1 26·338	17 52	−1 26·662	16 57	−1 26·549	± ·017	8 31·366	8 31·328	8 31·347	± ·019	......	·019
" 27.	9 52·537	9 52·493	W.	16 20	− 7·738	15 45	− 8·285	17 04	− 7·755	± ·011						
			E...	15 10	−1 28·676	18 02	−1 28·960	17 14	−1 28·881	± ·017	·411	·367	·389	± ·020	..	·022
" 28.	9 54·361	9 54·339	W.	15 45	− 8·285	19 00	− 8·281	16 58	− 8·283	± ·002						
			E...	18 02	−1 28·960	18 04	−1 31·335	17 08	−1 31·243	± ·018	·401	·379	·390	± ·018	....	·011
July 1.	10 01·926	10 01·904	W.	15 15	− 7·958	19 10	− 7·917	17 09	− 7·938	± ·010						
			E...	16 33	−1 38·387	19 13	−1 38·643	17 19	−1 38·461	± ·015	·403	·381	·392	± ·018	......	·011
" 2.	10 04·385	10 04·362	W.	16 20	− 7·857	19 00	− 7·964	17 17	− 7·895	± ·012						
			E...	16 19	−1 40·827	18 21	−1 41·040	17 27	−1 40·946	± ·014	·334	·311	·323	± ·018	..	·012
" 15.	10 32·109	10 32·067	W.	16 00	− 13·567	19 20	− 13·660	18 03	− 13·624	± ·013						
			E...	16 30	−2 14·147	19 21	−2 14·551	18 13	−2 14·390	± ·015	·343	·301	·322	± ·020	......	·021

Weighted mean .... m. 8 s. 31·361 s. ± ·007

Observers, West, W. F. King.
East, C. H. McLeod.

$\Delta\lambda$ .... 8 31·388 ± ·007

DIFFERENCE OF LONGITUDE BETWEEN OTTAWA AND WINNIPEG.

Date.	Difference of Chronograph. Western Signals.	Difference of Chronograph. Eastern Signals.	Station	Clock Correction. Before Signals. At T_1	Before Signals. ΔT	After Signals. At T_2	After Signals. ΔT	At Signals. At T	At Signals. T	ϵ	Difference of Longitude. Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	Time of Transmission.
1896.	h. m. s.	h. m. s.		h. m.	s.	h. m.	s.	h. m.	s.	s.	h. m. s.	h. m. s.	h. m. s.	s.	s.	s.
July 26.	1 25 36·919	1 25 36·541	W.	16 24	— 24·107	19 25	— 24·322	18 10	— 24·233	± ·016						
			E.	18 00	— 17·100	16 40	— 18·126	19 35	— 17·135	± ·017	1 25 44·017	1 25 43·639	1 25 43·828	± ·023	·028	·189
" 30.	35·252	34·885	W.	17 52	— 28·407	19 42	— 28·549	18 25	— 28·449	± ·012						
			E.	18 15	— 19·714	16 35	— 19·887	19 51	— 19·726	± ·012	43·975	·608	·792	± ·017	·008	·184
" 31.	34·360	33·994	W.	16 37	— 29·486	19 17	— 29·543	18 12	— 29·520	± ·010						
			E.	18 20	— 19·937	16 45	— 19·814	19 37	— 19·934	± ·012	43·946	·580	·763	± ·016	·037	·183
Aug. 2.	35·077	34·710	W.	17 02	— 28·859	20 00	— 27·221	18 26	— 28·774	± ·013						
			E.	18 25	— 19·840	18 30	— 20·127	19 51	— 19·857	± ·013	43·994	·627	·810	± ·018	·010	·184
" 3.	36·888	36·522	W.	17 02	— 28·859	20 00	— 27·221	18 30	— 27·312	± ·022						
			E.	18 30	— 20·127	21 10	— 20·120	19 56	— 20·123	± ·009	44·077	·711	·894	± ·024	·094	·183

Observers, West, W. F. King.
East, O. J. Klotz.

Weighted mean.................... h. m. s. 1 25 43·800 ± s. ·009

Date.	Western Signals.	Eastern Signals.	Station	At T_1	ΔT	At T_2	ΔT	At T	T	ϵ	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	Time of Transmission.
	h. m. s.	h. m. s.		h. m.	m. s.	h. m.	m. s.	h. m.	m. s.	s.	h. m. s.	h. m. s.	h. m. s.	s.	s.	s.
June 28.	1 21 35·497	1 21 35·130	W.	16 00	−4 16·791	15 30	−4 18·037	16 27	−4 16·815	± ·016						
			E.	15 45	— 8·285	19 00	— 8·281	17 49	— 8·282	± ·008	1 25 44·030	1 25 43·664	1 25 43·847	± ·018	.....	·183
" 29.	34·424	34·076	W.	15 30	−4 18·037	18 40	−4 18·177	17 00	−4 18·103	± ·007						
			E.	19 00	— 8·281	19 40	— 8·326	18 20	— 8·338	± ·028	44·204	43·856	44·030	± ·029	.....	·171
" 30.	33·096	32·746	W.	15 30	−4 19·124	18 00	−4 19·080	16 38	−4 19·104	± ·015						
			E.	15 50	— 8·037	19 00	— 8·087	18 00	— 8·071	± ·012	44·129	43·779	43·954	± ·019	.....	·175
July 1.	32·908	32·622	W.	15 30	−4 19·231	18 00	−4 18·960	16 55	−4 19·077	± ·013						
			E.	15 15	— 7·958	19 10	— 7·917	18 17	— 7·926	± ·010	44·059	43·773	43·916	± ·016	.....	·143
" 6.	26·224	25·908	W.	15 30	−4 26·928	18 10	−4 26·968	17 03	−4 26·951	± ·015						
			E.	17 30	— 9·100	18 40	10·125	18 24	9·136	± ·010	44·039	43·723	43·881	± ·018	.....	·158

Weighted mean.................... h. m. s. 1 25 43·910 ± s. ·009

Observers, West, O. J. Klotz.
East, W. F. King.

λ.................... 1 25 43·855 ± ·006

DIFFERENCE OF LONGITUDE BETWEEN PORT STANLEY AND OTTAWA.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	
1896.	m. s.	m. s.	m. s.	s.	m. s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
Oct. 11...	1 46·275	1 46·128	21 23·902	±·010	−1 8·885	±·013	22 01·292	22 01·145	22 01·219	±·016	·128	·073
" 13...	34·388	34·245	34·457	±·012	− 7·715	±·010	01·130	00·987	01·058	±·016	·033	·072
" 14...	27·948	27·820	40·159	±·009	− 6·923	±·011	01·184	01·056	01·120	±·014	·029	·064
" 15...	21·032	20·904	46·201	±·011	− 6·211	±·012	01·022	00·894	00·958	±·016	·133	·064

Weighted mean .... 22 m. 01·091 s. ±·008 s.

Observers, West, O. J. Klotz.
East, W. F. King.

Date.	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	Time of Transmission.
	h. m. s.	h. m. s.	m. s.	s.	h. m. s.	s.	m. s.	m. s.	m. s.	s.		s.
Nov. 3...	2 56 59·876	2 56 59·736	+00 06·618	±·015	2 34 52·656	±·008	22 00·602	22 00·462	22 00·532	±·017	......	·070
" 13...	55 44·905	55 44·792	−00 04·364	±·016	− 52·584	±·008	·685	·572	·629	±·018	....	·056
" 16...	55 17·484	55 17·369	−01 29·501	±·009	− 46·205	±·010	·780	·665	·722	±·014	......	·057
" 22...	54 24·778	54 24·651	−02 15·589	±·010	− 39·649	±·007	·718	·591	·654	±·012	....	·064
" 24...	54 07·070	54 06·946	−02 30·518	±·009	− 36·789	±·008	·859	·735	·797	±·012	......	·062

Weighted mean ...... 22 m. 00·638 s. ±·007 s.
ΔλPG .... 22 00·865 ±·006

Observers, West, W. F. King.
East, O. J. Klotz.

DIFFERENCE OF LONGITUDE BETWEEN ROSE POINT AND OTTAWA.

Date.	Difference of Chronograph. Western Signals.	Difference of Chronograph. Eastern Signals.	Clock Correction. Western Station.	Probable Error.	Clock Correction. Eastern Station.	Probable Error.	Difference of Longitude. Western Signals.	Difference of Longitude. Eastern Signals.	Mean.	Probable Error.	v.	Time of Transmission.
1900.	m. s.	m. s.	s.	s.	s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
May 19...	17 23·264	17 23·228	43·882	±·018	40·410	±·013	17 19·792	17 19·756	17 19·774	±·020	·004	·018
" 21....	28·297	28·276	46·621	±·013	38·032	±·012	·708	·687	·697	±·018	·081	·011
" 23....	36·498	36·465	49·296	±·017	32·714	±·019	·916	·883	·899	±·025	·121	·016
" 25 ..	44·499	44·476	51·933	±·010	27·408	±·012	·965	·951	·958	±·016	·180	·007
" 28 ..	57·611	57·554	56·351	±·011	18·333	±·013	·593	·536	·564	±·017	·214	·029

Weighted mean.... ... 17 m. 19·778 s. ±·008 s.

Observers, West, O. J. Klotz.
East, F. W. O. Werry.

Date.	Difference of Chronograph. Western Signals.	Difference of Chronograph. Eastern Signals.	Clock Correction. Western Station.	Probable Error.	Clock Correction. Eastern Station.	Probable Error.	Difference of Longitude. Western Signals.	Difference of Longitude. Eastern Signals.	Mean.	Probable Error.	v.	Time of Transmission.
	m. s.	m. s.	m. s.	s.	s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
June 4....	18 33·446	18 33·387	1 07·631	±·018	− 5·786	±·012	17 20·029	17 19·970	17 19·999	±·023	·046	·029
" 5 ..	39·027	38·995	09·866	±·012	− 9·025	±·009	20·136	20·104	20·120	±·015	·075	·016
" 8 ..	53·352	53·324	15·525	±·015	−17·867	±·009	19·960	19·932	19·946	±·018	·099	·014
" 9....	58·181	58·127	17·618	±·012	−20·477	±·011	20·086	20·032	20·059	±·016	·014	·027

Weighted mean........ 17 m. 20·045 s. ±·008 s.

Mean λ .. .. 17 19·911 ±·006

Observers, West, F. W. O. Werry.
East, O. J. Klotz.

DIFFERENCE OF LONGITUDE BETWEEN OWEN SOUND AND OTTAWA.

Date.	Difference of Chronograph. Western Signals.	Eastern Signals.	Clock Correction. Western Station.	Probable Error.	Eastern Station.	Probable Error.	Difference of Longitude. Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	Time of Transmission.
1900.	m. s.	m. s.	m. s.	s.	m. s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
June 19....	19 39·941	19 39·865	−2 03·019	± ·010	−46·097	± ·011	20 56·863	20 56·787	20 56·825	± ·015	·154	·038
" 20....	45·260	45·180	−2 00·014	± ·019	−48·548	± ·014	·726	·646	·686	± ·023	·015	·040
" 22....	55·620	55·540	−1 54·512	± ·011	−53·587	± ·011	·545	·465	·505	± ·015	·166	·040
" 23....	20 00·830	20 00·750	−1 51·858	± ·013	−55·963	± ·023	·725	·645	·685	± ·026	·014	·040

Weighted mean .. ... 20 m. 56·671 s. ± ·009 s.

Observers, West, L. B. Stewart.
East, F. W. O. Werry.

Date.	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	Time of Transmission.
	m. s.	m. s.	m. s.	s.	m. s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
July 4...	20 47·940	20 47·848	−1 28·484	± ·017	−1 19·518	± ·014	20 56·906	20 56·814	20 56·860	± ·022	·082	·046
" 6....	56·040	56·000	−1 25·073	± ·021	−1 24·343	± ·014	·770	·730	·750	± ·025	·028	·020
" 15	21 29·228	21 29·158	−1 12·176	± ·011	−1 44·749	± ·012	·664	·594	·629	± ·016	·149	·035
" 18....	38·280	38·210	−1 07·380	± ·010	−1 48·730	± ·012	·930	·860	·895	± ·016	·117	·035

Weighted mean........ 20 m. 56·778 s. ± ·010 s.

λ .... 20 56·724 ± ·007

Observers, West, F. W. O. Werry.
East, L. B. Stewart.

DIFFERENCE OF LONGITUDE BETWEEN OTTAWA AND CHALK RIVER.

Date	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	
1900.	m. s.		m. s.	s.	s.	s.	m. s.			s.		
July 25	1 39·550		−6 14·240	±·039	−55·790	±·015	6 58·000			±·042		
" 26	41·990		12·420	±·027	−56·520	±·014	57·890			±·031		
" 27	44·975		− 10·140	±·026	57·140	±·014	57·975			±·029		
" 28	48·100		08·510	±·040	58·370	±·013	58·240			±·042		

	m. s.	s.
Weighted mean	6 57·998	±·017
Personal equation	·508	±·051
$\Delta\lambda$	6 58 506	±·054

Observers, West, L. B. STEWART.
East, O. J. KLOTZ.

DIFFERENCE OF LONGITUDE BETWEEN OTTAWA AND VANCOUVER.

Date.	Difference of Chronograph. Western Signals.	Eastern Signals.	Station.	Clock Correction. Before Signals. At T_1	T	After Signals. At T_2	T	At Signals. At T	T	ε	Difference of Longitude. Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	Time of Transmission.
1900.	h. m. s.	h. m. s.		h. m.	m. s.	h. m.	m. s.	h. m.	m. s.	s.	h. m. s.	h. m. s.	h. m. s.	s.	s.	s.
Aug. 18.	2 59 14·770	2 59 14·430	W	18 30	−12 37·470	21 00	−12 37·930	19 31	12 37·657	±·014						
			E..	20 30	2 13 900	18 50	− 2 13 860	22 30	2 13 896	±·016	3 09 38·531	3 09 38 191	3 09 38·361	±·021	·124	·170
" 19	11·330	10·950	W	18 50	12 40·810	21 20	−12 41·240	19 38	−12 40·948	·013						
			E..	20 20	2 13·870	18 30	− 2 14 210	22 37	− 2 13 905	·016	·373	37 990	·182	±·020	·055	·190
" 20.	08·490	08 150	W	18 20	12 44 100	21 00	−12 44 350	19 44	−12 44 233	·019						
			E..	20 20	2 14·230	18 30	− 2 16 410	22 43	− 2 14 343	·009	·380	38·040	·210	±·021	·027	·170
" 25.	03 430	03 070	W	19 10	12 54·470	21 30	−12 58 840	20 05	−12 54·61	·015						
			E..	20 20	2 19 580	.	....	23 04	− 2 19·655	·009	·390	38·030	·210	± 018	·027	·180

	h. m. s.	s.
Weighted mean..........	3 09 38 237	·010

Observers, West, W. F. King.
East, O. J. Klotz.

Date.	Western Signals.	Eastern Signals.	Station.	At T_1	T	At T_2	T	At T	T	ε	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	Time of Transmission.
	h. m. s.	h. m. s.		h. m.	m. s.	h. m.	m. s.	h. m.	m. s.	s.	h. m. s.	h. m. s.	h. m. s.	s.	s.	s.
Sept. 9.	2 55 09.560	2 55 09 200	W	....	....	22 10	16 48·110	20 53	16 47·968	017						
			E..	21 20	− 2 18 8[illegible]0	25 50	2 19 010	23 48	− 2 18·947	012	3 09 38·581	3 09 38·221	3 09 38·401	·021	660	·180
" 14	2 55 01·600	2 55 01 220	W	21 20	−17 02·190	....	....	21 23	17 02 190	021						
			E..	21 20	− 2 24 870	25 00	− 2 25·120	24 18	2 25·092	·015	·698	318	·508	·026	410	190
" 17.	55 00·310	54 59 950	W	20 10	−17 09 310	22 40	−17 09·800	21 30	17 09·571	·013						
			E..	23 40	− 2 31·200	25 00	− 2 31 270	24 25	2 31·239	012	·642	·282	·462	018	·050	·180
" 18.	54 59 580	54 59·220	W	20 20	−17 11·810	23 00	−17 12·270	21 56	17 12 086	·022						
			E..	22 50	− 2 32 960	25 40	− 2 32 990	24 51	2 32·981	·009	·685	·325	·505	·021	·380	·180

	h. m. s.	s.
Weighted mean..................	3 09 38·467	·011
Δλ..........................	3 09 38·352	± 007

Observers, West. O. J. Klotz.
East, W. F. King.

DIFFERENCE OF LONGITUDE BETWEEN RAYSIDE AND OTTAWA.

Date.	Difference of Chronograph. Western Signals.	Difference of Chronograph. Eastern Signals.	Clock Correction. Western Station.	Clock Correction. Probable Error.	Clock Correction. Eastern Station.	Clock Correction. Probable Error.	Difference of Longitude. Western Signals.	Difference of Longitude. Eastern Signals.	Difference of Longitude. Mean.	Difference of Longitude. Probable Error.	Difference of Longitude. r.	Time of Transmission.
1900.	m. s.	m. s.	m. s.	s.	s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
July 25....	20 51·777	20 51·724	— 1 36·830	± ·016	— 55·772	± ·015	21 32·835	21 32·782	21 32·808	± ·021	·058	·027
" 26....	54·100	54·036	— 1 35·173	± ·012	— 56·510	± ·0 0	·763	·699	·731	± ·015	·019	·032
" 27....	58·190	58·110	— 1 31·734	± ·010	— 57·143	± ·010	·781	·701	·741	± ·014	·039	·040
" 28....	03·140	03·060	— 1 27·990	± ·008	— 58·339	± ·009	·791	·711	·751	± ·012	·001	·040

Observers, West, F. W. O. Werry,
East, O. J. Klotz.

Weighted mean .... 21 m. 32·750 s. ± ·007

Date.	Difference of Chronograph. Western Signals.	Difference of Chronograph. Eastern Signals.	Clock Correction. Western Station.	Clock Correction. Probable Error.	Clock Correction. Eastern Station.	Clock Correction. Probable Error.	Difference of Longitude. Western Signals.	Difference of Longitude. Eastern Signals.	Difference of Longitude. Mean.	Difference of Longitude. Probable Error.	Difference of Longitude. r.	Time of Transmission.
	m. s.	m. s.	s.	s.	m. s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
Oct. 9....	22 37·330	22 37·290	— 43·240	± ·015	— 1 48·248	± ·011	21 32·322	21 32·282	21 32·302	± ·019	·029	·020
" 10....	36·892	36·852	— ·225	± ·020	— 1 47·920	± ·010	·197	·157	·177	± ·022	·096	·020
" 11....	36·436	36·390	— ·467	± ·020	— 1 47·538	± ·013	·365	·319	·342	± ·024	·069	·023

Observers, West, O. J. Klotz,
East, F. W. O. Werry.

Weighted mean .... 21 m. 32·273 s. ± ·012 s.

Λ .... 21 32·512 ± ·007

DIFFERENCE OF LONGITUDE BETWEEN WILNO AND OTTAWA.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	v.	
1900	m. s.	m. s.	m. s.	s.	m. s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
Aug. 20....	1 22·70	1 22·74	11 01·664	± ·036	− 2 14·246	± ·009	7 24·718	7 24·678	7 24·698	± ·037	·060	·020
" 24...	1 07·68	− 1 07·76	−10 51·605	± ·039	− 2 19·036	± ·011	·889	·809	·849	± ·040	·091	·040

	m. s.	s.
Weighted mean	7 24·758	± ·026
Personal equation	− ·082	± ·005
λ	7 24·676	± ·026

Observers, West, F. W. O. Werry,
East, O. J. Klotz.

DIFFERENCE OF LONGITUDE BETWEEN OTTAWA AND CANOE LAKE.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	
1900	m. s.	m. s.	s.	s.	m. s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
Sept. 13	13 47·920	13 47·910	— 40·492	± ·032	— 2 23·288	± ·008	12 05·124	12 05·114	12 05 119	± ·033	·135	·005
" 14	13 52·786	....	— 37·616	± ·030	— 2 25·010	± ·012	·392	....	·392	± ·032	·138	......
" 17	14 12·280	14 12·250	— 24·176	± ·022	— 2 31·200	± ·017	·256	·226	·241	± ·028	·013	·015

	m. s.	s.
Weighted mean	12 05·254	± ·012
Personal equation	— ·340	
$\Delta\lambda$	12 04·914	

Observers, West, F. W. O. Werry,
East, W. F. King.

DIFFERENCE OF LONGITUDE BETWEEN VANCOUVER AND MIDWAY.

Date.	Difference of Chronograph. Western Signals.	Difference of Chronograph. Eastern Signals.	Clock Correction. Western Station.	Probable Error.	Clock Correction. Eastern Station.	Probable Error.	Difference of Longitude. Western Signals.	Difference of Longitude. Eastern Signals.	Mean.	Probable Error.	r.	Time of Transmission.
1901.	m. s.	m. s.	s.	s.	s.	s.	m. s.	m. s.	m. s.	s.		s.
Aug. 14....	17 51·233	17 51·057	23·477	± ·013	08·311	± ·014	17 19·445	17 19·269	17 19·357	± ·019	.....	·088
" 15....	49·485	49·241	19·660	± ·015	— 10·199	± ·013	·626	·382	·504	± ·020	....	·122
" 16	47·982	47·813	16·428	± ·011	— 12·326	± ·021	·228	·059	·144	± ·024	.....	·084
" 18....	48·270	48·102	12·290	± ·009	— 16·618	± ·014	·362	·194	·278	± ·017	....	·084
" 20....	50·302	50·136	8·543	± ·010	— 22·304	± ·015	·455	·289	·372	± ·018	....	·083
" 21....	50·901	50·714	5·860	± ·013	— 25·518	± ·014	·523	·336	·430	± ·019	....	·093

	m.	s.		s.
Weighted mean......	17	19·355	±	·008
Personal equation		·001	±	·013
$\Delta\lambda$	17	19·354	±	·015

Observers, West, O. J. Klotz.
East. F. W. O. Werry.

DIFFERENCE OF LONGITUDE BETWEEN THREE RIVERS AND OTTAWA.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	
1902.	m. s.	m. s.	m. s.	s.	m. s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
May 10....	10 26·697	10 26·661	— 2 28·789	± ·012	— 0 14·147	± ·015	12 41·339	12 41·303	12 41·321	·019	·104	·018
" 14....	10 41·879	10 41·801	— 2 34·773	± ·011	— 0 35·132	± ·026	·520	·442	·481	·028	·056	·039
" 16....	10 49·300	10 49·262	— 2 37·338	± ·011	— 0 45·130	± ·014	·508	·470	·489	·018	·064	·019
" 17....	10 53·098	10 53·034	— 2 38·707	± ·015	— 0 50·390	± ·013	·415	·351	·383	·020	·042	·032
" 20...	11 03·688	11 03·639	— 2 43·717	± ·008	— 1 05·930	± ·013	·475	·426	·451	·015	·026	·025

	m.	s.		s.
Weighted mean	12	41·425	±	·008
Personal equation........		—·018	±	·013
$\Delta\lambda$..........................	12	41·407	±	·015

Observers, West, W. F, King.
East, C. A. Bigger.

DIFFERENCE OF LONGITUDE BETWEEN WHITE RIVER AND OTTAWA.

Date.	Difference of Chronograph. Western Signals.	Difference of Chronograph. Eastern Signals.	Clock Correction. Western Station.	Clock Correction. Probable Error.	Clock Correction. Eastern Station.	Clock Correction. Probable Error.	Difference of Longitude. Western Signals.	Difference of Longitude. Eastern Signals.	Difference of Longitude. Mean.	Difference of Longitude. Probable Error.	Difference of Longitude. r.	Time of Transmission.
1902.	m. s.	m. s.	s.	s.	m. s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
June 10....	41 44·842	41 44·732	− 00·505	± ·018	− 3 27·597	± ·017	38 17·750	38 17·640	38 17·695	± ·025	·017	·055
" 15....	34·958	34·848	− 21·370	± ·011	− 3 38·802	± ·019	·526	·416	·471	± ·024	·207	·055
" 16....	33·323	33·227	− 26·301	± ·017	− 3 40·916	± ·019	·708	·612	·660	± ·026	·018	·048
" 17....	30·313	30·200	− 30·650	± ·028	− 3 43·103	± ·013	·860	·747	·803	± ·031	·125	·057
" 19....	25·278	25·143	− 40·028	± ·016	− 3 47·459	± ·010	·847	·712	·780	± ·019	·102	·067
" 27....	11·201	11·095	− 72·087	± ·019	− 4 05·587	± ·015	·701	·595	·648	± ·025	·030	·053

	m.	s.		s.
Weighted mean	38	17·678	±	·010
Personal equation		·051	±	·012
λ	38	17·627	±	·016

Observers, West, F. W. O. Werry.
East, O. J. Klotz.

DIFFERENCE OF LONGITUDE BETWEEN PORTNEUF AND OTTAWA.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	v.	
1903.	m. s.	m. s.	m. s.	s.	s.	s.	m. s.	m. s.	m. s.	s.		s.
Sept. 2....	11 09·583	11 09·525	— 4 40·394	± ·010	— 34·151	± ·007	15 15·806	15 15·748	15 15·777	± ·012	....	·029
" 5....	05·294	05·209	49·673	± ·011	— 39·153	± ·011	·814	·729	·772	± ·015	....	·042
" 7....	10 59·164	10 59·109	— 55·829	± ·012	— 39·126	± ·011	·867	·812	·839	± ·016	....	·027
" 8....	57·054	56·992	— 58·897	± ·007	— 40·117	± ·009	·834	·772	·803	± ·011	....	·031
" 11..	46·900	46·801	— 5 08·385	± ·010	— 39·416	± ·010	·869	·770	·819	± ·017	....	·049

	m.	s.		s.
Weighted mean...............	15	15·799	±	·006
Personal equation..............		— ·146	±	·007
λ...........................	15	15·653	±	·009

Observers, West, F. A. McDiarmid.
East, C. A. Bigger.

DIFFERENCE OF LONGITUDE BETWEEN WOODSTOCK AND OTTAWA.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	
1903.	m. s.	m. s.	s.	s.	m. s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
October 12..	22 02·278	22 02·228	3·799	± ·012	− 1 43·759	± ·009	20 14·720	20 14·670	20 14·695	± ·015	·000	·025
" 13..	04·607	04·571	3·118	± ·009	− 1 46·762	± ·009	·727	·691	·709	± ·013	·014	·018
" 14..	07·704	07·635	3·188	± ·010	− 1 49·775	± ·008	·741	·672	·707	± ·013	·012	·034
" 20..	20·444	20·377	− 1·471	± ·011	− 2 07·221	± ·011	·694	·627	·661	± ·015	·034	·034

	m. s.	s.
Weighted mean................	20 14·695	± ·007
Personal equation............	·146	± ·007
Δλ...........................	20 14·841	± ·010

Observers, West, C. A. Bigger.
East, F. A. McDiarmid.

DIFFERENCE OF LONGITUDE BETWEEN HARRISTON AND OTTAWA.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	
1904.	m. s.	m. s.	s.	s.	m. s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
August 17.	22 15·610	22 15·504	− 11·986	± ·014	− 1 48·319	± ·015	20 39·277	20 39·171	20 39·224	± ·020	·035	·053
" 18.	17·483	17·407	− 13·427	± ·014	− 1 51·669	± ·015	39·241	39·165	39·203	± ·020	·056	·038
" 22.	25·977	25·886	− 18·8[illegible]0	± ·015	− 2 05·474	± ·010	39·393	39·302	39·347	± ·01	·088	·046

	m. s.	s.
Weighted mean	20 39·259	± ·012
Personal equation	·007	± ·013
λ	20 39·252	± ·018

Observers, West, F. W. O. Werry.
East, R. M. Stewart.

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DIFFERENCE OF LONGITUDE BETWEEN OTTAWA AND BEETON.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	v.	
1904.	m. s.	m. s.	s.	s.	m. s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
Sept. 5 ...	19 14·839	19 14·734	1·434	± ·018	− 2 55·821	± ·009	16 17·584	16 17·479	16 17·531	± ·020	·004	·053
" 6 ...	18·483	18·375	1·326	± ·015	− 2 59·566	± ·010	·591	·483	17·537	± ·018	·002	·054

	m. s.	s.
Weighted mean..................	16 17·535	± ·001
Personal equation...............	− ·007	± ·013
λ..............................	16 17·528	± ·013

Observers, West, F. W. O. Werry.
East, R. M. Stewart.

DIFFERENCE OF LONGITUDE BETWEEN GUELPH AND OTTAWA.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	
1904.	m. s.	m. s.	s.	s.	m. s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
Sept. 12....	21 34·911	21 34·819	2·508	± ·011	— 3 21·800	± ·007	18 10·603	18 10·511	18 10·557	± ·013	·005	·046
" 13....	39·887	39·811	3·760	± ·014	— 25·503	± ·014	10·624	10·548	10·586	± ·019	·034	·038
" 17....	58·227	58·134	7·322	± ·017	— 40·330	± ·009	10·575	10·481	10·528	± ·019	·024	·046
" 19....	22 06·557	22 05·482	8·351	± ·017	— 47·639	± ·009	10·567	10·492	10·529	± ·019	·023	·038

	m. s.	s.
Weighted mean................	18 10·552	± ·009
Personal equation..........	— ·007	± ·013
ΔΛ.........................	18 10·545	± ·016

Observers, West, F. W. O. Werry.
East, R. M. Stewart.

DIFFERENCE OF LONGITUDE BETWEEN OTTAWA AND ORILLIA.

Date.	Difference of Chronograph.		Clock Correction.				Difference of Longitude.					Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Probable Error.	Eastern Station.	Probable Error.	Western Signals.	Eastern Signals.	Mean.	Probable Error.	r.	
1904.	m. s.	m. s.	s.	s.	m. s.	s.	m. s.	m. s.	m. s.	s.	s.	s.
Sept. 26....	18 55·174	18 55·087	− 7·275	± ·015	− 4 12·485	± ·009	14 49·964	14 49·877	14 49·921	± ·018	·048	·044
" 29 ...	19 07·310	19 07·241	− 5·921	± ·016	23·179	± ·007	50·052	49·983	50·017	± ·018	·048	·035

	m. s.	s.
Weighted mean..	14 49·969	± ·013
Personal equation....	− ·007	± ·013
$\Delta\lambda$	14 49·962	± ·018

Observers, West, F. W. O. Werry.
East, R. M. Stewart.

SYNOPSIS OF OBSERVED DIFFERENCES OF LONGITUDE, AND THE LONGITUDE OF STATIONS, 1885-1904.

Place.	Year.	Difference of Longitude. h.	m.	s.	ε	To	Longitude. h.	m.	s.	ε	Longitude. °	′	″	″
Victoria	1885	+	4	06·994		Seattle (1885)	8	13	26·444		123	21	36·66	
Port Moody	1885	+	10	05·108		Kamloops (1885)	8	11	26·685		122	51	40·27	
Revelstoke	1886	—	8	28·970	± ·022	" (1886)	7	52	49·847		118	12	27·70	
Field	1886	—	15	18·953	± ·020	"	7	45	59·864		116	29	57·96	
Calgary	1886	—	25	03·659	± .020	"	7	36	15·158		114	03	47·37	
Kamloops	1886	+ 1	32	47·157	± ·019	Winnipeg (Old Observatory)	8	01	18·817		120	19	42·25	
Wapella	1887	+	19	21·505	± ·021	" "	6	47	53·165		101	58	17·47	
Port Arthur	1887	—	31	40·192	± ·031	" "	5	56	51·468		89	12	52·02	
Kalmar	1887	—	8	40·476	± ·021	" "	6	19	51·184		94	57	47·76	
Edmonton	1888	+ 1	05	27·965	± ·015	" (New Observatory)	7	34	01·867		113	30	28·00	
Onion Lake	1888	+	51	26·833	± ·013	" "	7	20	00·735		110	00	11·02	
Mattawa	1890	+	11	59·020	± ·022	Ottawa	5	14	49·042	± ·059	78	42	15·63	± ·88
Ottawa	1896	+	8	31·388	± ·007	Montreal	5	02	50.022	± ·053	75	42	30·33	± ·81
Winnipeg	1896	+ 1	25	43·855	± ·006	Ottawa	6	28	33·877	± ·053	97	08	28·15	± ·82
Port Stanley	1896	+	22	00·865	± ·006	"	5	24	50·887	± ·054	81	12	43·30	± ·81
Rose Point	1900	+	17	19·911	± ·006	"	5	20	09·933	± ·054	80	02	28·99	± ·81
Owen Sound	1900	+	20	56·724	± ·007	"	5	23	46·746	± ·055	80	56	41·19	± ·82
Chalk River	1900	+	6	58·506	± ·054	"	5	09	48·528	± ·076	77	27	07·92	± 1·14
Vancouver	1900	+ 3	09	38·352	± ·007	"	8	12	28·374	± ·055	123	07	05·61	± ·82
Rayside	1900	+	21	32·512	± ·007	"	5	24	22·534	± ·054	81	05	38·01	± ·81
Wilno	1900	+	7	24·676	± ·026	"	5	10	14·698	± ·060	77	33	40·47	± ·90
Canoe Lake	1900	+	12	04·914		"	5	14	54·936		78	43	44·04	
Midway	1901	—	17	19·354	± ·015	Vancouver	7	55	09·020		118	47	15·30	
Three Rivers	1902	—	12	41·407	± ·015	Ottawa	4	50	08·615	± ·056	72	32	09·22	± ·84
White River	1902	+	38	17·627	± ·016	"	5	41	07·649	± ·056	85	16	54·73	± ·84
Portneuf	1903	—	15	15·653	± .009	"	4	47	34·369	± ·055	71	53	35·53	± ·82
Woodstock	1903	+	20	14·841	± ·010	"	5	23	04·863	± ·055	80	46	12·94	± ·82
Harriston	1904	+	20	39·252	± ·018	"	5	23	29·274	± ·057	80	52	19·11	± ·85
Beeton	1904	+	16	17·528	± ·013	"	5	19	07·550	± ·055	79	46	53·25	± ·82
Guelph	1904	+	18	10·545	± ·016	"	5	21	00·567	± ·056	80	15	08·50	± ·84
Orillia	1904	+	14	49·962	± ·018	"	5	17	39·984	± ·057	79	24	59·76	± ·85

APPENDIX 8.

REPORT ON FIELD OPERATIONS IN THE GEOLOGY OF THE MOUNTAINS CROSSED BY THE INTERNATIONAL BOUNDARY (49TH PARALLEL), BY R. A. DALY, PH.D.

OTTAWA, Ont., December 30, 1905.

W. F. KING, Esq., B.A., LL.D., D.T.S., &c.,
International Boundary Commissioner,
Ottawa.

SIR,—I have the honour to submit herewith my report upon my field operations in the geology of the mountains crossed by the international boundary.

In August of this year I was officially notified of my transfer from the Department of the Geological Survey to your department. In accordance with instructions, therefore, I herewith present a brief account of the work done during the past year. My four previous annual statements are printed in the summary report of the Geological Survey department.

The winter of 1904-5 was occupied with the preparation of the final report on the geology of the boundary mountains. Within the year I have also written five papers founded on special studies of that geology. Those on 'The Accordance of Summit Levels among Alpine Mountains,' and on 'The Classification of Igneous Intrusive Bodies' have been published in the *Journal of Geology*; that on 'The Secondary Origin of Certain Granites,' in the *American Journal of Science*. A paper on 'Magmatic Differentiation through Gravitative Adjustment' and another on 'The Nomenclature of the Mountains crossed by the 49th Parallel Boundary between Canada and the United States,' have not yet been published. A sixth paper on 'Machine-made Line Drawings for the Illustration of Scientific Papers' was published in the *American Journal of Science*, and reprinted in the weekly *Science*.

On May 16 I left Ottawa for Gateway, Montana, the point on the boundary where I closed the field-work at the close of the season of 1904. My party, including an assistant, a packer and a cook, was immediately outfitted and went into camp. Mr. Fred. Nelmes of Chilliwack had done such excellent service as assistant in three out out of the four preceding seasons that I engaged him again this year in the same capacity. A little delay was occasioned by rains in June and, at the first, by deep winter snow still covering summits on the commission trails east of Gateway, but, in the main, it was found possible to pursue the work steadily throughout the season. The geological map of the boundary belt was completed to the summit of the Rocky Mountains, and a structure-section carried from there to the Great Plains at Waterton lake. Then a rapid journey via Chief mountain and the Swift Current pass brought the party, on June 26, to Belton, Montana and again to the railroad. There the party was disbanded, and, with my assistant, I went to Midway, B.C., and Loomis, Washington. At Midway I met Mr. McDiarmid of the boundary surveys staff. He was kind enough to let me have three horses from his pack-train. Two men and four additional horses were hired at Loomis for this second part of the season. Field work was resumed on August 3 at the Similkameen river, and the geology of the belt westward to the Skagit river was completed on September 9. Beyond the Skagit the boundary belt has not yet been mapped. It was, therefore, inexpedient to attempt any

systematic work on that side of the river. Continued bad weather and the failure of supplies hastened us to Hope station where I disbanded the party and returned to Ottawa on September 16.

The total area geologically mapped in detail was about 625 square miles. Notwithstanding the exceeding ruggedness of both parts of the Cordillera crossed this season, it was possible to cover so great an area partly because of favourable weather for most of the season, and partly because of the many excellent trails already cut through the forests by the topographic and monument-setting parties. These trails rendered every part of the boundary belt accessible.

The third and most important reason for such rapid work is that, as in the previous season, I had the advantage of using admirable contour maps of the regions studied. These were photographic copies of the original manuscript plane-table sheets of the United States topographers attached to the commission. I have pleasure in recording the great accuracy and completeness of these maps as well as in acknowledging the kindness of the United States officials who so generously supplied them.

This opportunity of working out the structural geology with the aid of an accurate contour map already in the hands of the geologist as he goes into the field is all but unique in the history of geological investigation in Canada. That such a map is of incomparable aid to the geologist is recognized by every worker in the rough western mountains, as, indeed, it was recognized fifty years ago in the far easier country of Europe and eastern Canada by such masters as Sir Roderick Murchison and Sir William Logan. It is not too much to say that a thorough as well as accurate record of the constitution and anatomy of a western mountain range is quite impossible unless the geologist is supplied with the antecedent topographic data of a contour map. A fortiori, the economic geologist, necessarily covering his mining camp or mining district with still greater detail, needs his contour map ready to hand.

The total length of the boundary belt between the Great Plains and the Pacific is about 425 miles. The geology has now been worked out for parts of the belt aggregating 380 miles, of which 16 miles have been surveyed in detail by Professor Brock. A section 14 miles long has never been traversed; about 30 miles of the belt require some supplementary field work.

The main object of my field work this season, as in the other four seasons on the boundary, has been to develop a continuous structure section across the many mountain axes of the Cordillera. Though the width of the belt studied is small (from 5 to 10 miles) it has proved possible to construct such a section as shall fairly represent the staple, average formations and structures characteristic of this part of the Cordillera.

The first part of the season was concerned with the Rocky mountain range proper. At the 49th parallel this range is very clearly divided into two great sub-ranges separated by the broad and deep longitudinal valley of the Flathead river. The western sub-range, thus extending from the even greater valley of the Kootenay river at Gateway eastward to the Flathead, has been called the Galton range; it includes the subordinate McDonald range immediately overlooking the Flathead. The eastern sub-range is double. From the Flathead to the wide open valley occupied in part by Waterton lake, the mountains belong to the Livingstone range. From Waterton lake to the Great Plains, the 49th Parallel crosses the narrower Lewis or Wilson range.

The scenic quality of the Lewis and Livingstone ranges is quite similar to that along the main line of the Canadian Pacific Railway. In ruggedness and grandeur of form, as in the colouring of their countless cliffs and peaks, the mountains of these two ranges are the most impressive on the boundary line. Their only possible rivals for this pre-eminence are the high Cascades east and west of the Skagit river. The Galton range is, not only in geographical position but also in composition and scenery, intermediate between the superb Livingstone range and the tamer Purcell range west of Tobacco Plains.

As in the Purcells, the rocks of the Galton and more easterly ranges are chiefly sedimentary. A stratigraphic column was worked out for the Galton range and another for the Livingstone range. In each column there are represented twelve con-

formable, stratified members aggregating about 15,000 feet in thickness. The respective members were, in general, found to match well on the two sides of the Flathead valley. The lower part of this thick series carries fossils of pre-Cambrian age. On lithological grounds the upper 7,000 feet of each column is tentatively correlated with the fossiliferous Cambrian rocks of the Castle Mountain series, described by Mr. McConnell on the main line of the Canadian Pacific Railway. Three relatively small blocks of massive 'Devono-Carboniferous' limestone, showing a maximum thickness of more than 2,500 feet, are faulted down into the staple Cambrian-pre-Cambrian series. The only other bed-rock sedimentary formation in this part of the belt is a fresh-water, fossiliferous tertiary deposit occurring in the Flathead valley.

Near the top of the Cambrian stratified group is a contemporaneous volcanic formation varying in thickness from 250 to 400 feet or more. It shows a most remarkable persistence and extent and serves as a valuable horizon-marker among the old sediments of the Purcell range and the Rocky mountains proper. This lava was traced through seventy-five miles of the boundary belt and was seen in its usual relations at Altyn, Montana, 100 miles or more from its western outcrop, on the 49th parallel. An intrusive sheet of basic rock which apparently functioned as a feeder to the ancient volcanic vents, occurs a few hundred feet lower in the Cambrian. This sheet also shows great persistence in the adjacent parts of Montana, Alberta, and British Columbia.

The conformable Cambrian-pre-Cambrian sedimentaries thus studied in the Rocky mountains were found to be equivalent in age to the sedimentary formations of the Purcell range and to others in the southern Selkirk range west of the Kootenay at Port Hill. This discovery furnishes the key to the structural and stratigraphic geology of the continuous belt from the Columbia river at Boundary town eastward to the Great Plains, a distance of 175 miles. In this latitude the general geology of the Cordillera for about two-fifths of its entire width between the sea and the Great Plains is largely included in the history of a single, thick group of sea-bottom deposits. In the southern Selkirks this group is coarse-grained and heterogeneous, composed largely of grits, conglomerates and quartzites laid down near the old zone of shore-lines. In the Purcell range to the eastward and farther from that coast-line zone, the sediments are, in general, medium to fine-grained sandstones and notably homogeneous. In the Rockies proper the group is again heterogeneous but made up chiefly of argillites, limestones and dolomites, all rocks deposited relatively far from shore. The 49th parallel thus affords a line of cross-section with reference to the structural and orographic axes of the Cordillera and also an exceptionally continuous transverse section of the rock-formations that have filled a single submarine down-warp or 'geosynclinal.'

The time spent in the Rockies proper was mostly occupied in delimiting the various formations and in working out the faults and folds incident to the upbuilding of the mountains. It would be inappropriate to enter on details in a report like this. In general, the structures due to rock-dislocation show a steadily increasing complexity as one follows the belt from the Great Plains to the Columbia river. Throughout that distance the dislocation has developed much normal faulting and thrusting; folding is distinctly subordinate.

The petroleum problem of southern Alberta and of the Flathead valley is intimately related to the structural geology of the Livingstone range. Active prospecting for commercial deposits of oil has been carried on for some years and is now winning more attention than ever. The problem has special interest and special difficulty of analysis since the oil seepages of the region, as at Waterton lake, in Oil creek (Cameron Falls brook) valley, and in the Kintla lake canyon, are located at fissures in the pre-Cambrian stratified formations. Commercial petroleum has never been found in rocks so old as these and the great majority of the world's authorities in rock-oil consider that the reason is clear. They do not expect petroleum to occur in commercial quantities in pre-Cambrian formations, because those formations carry almost negligible amounts of organic debris, such as is regarded by these authorities as the original source of the petroleum substance. The hypothesis of an inorganic origin for petroleum has long been advocated by individual writers on the subject, but they have not

proved their case, nor yet produced a body of arguments so compact and cogent as those advanced for the organic theory. Even in the peculiar case of the Alberta field the evidence bearing on the question seems to be adverse to the inorganic theory.

The thick 'Devono-Carboniferous' limestone of the region is bituminous through a large part of its exposed thickness. So far as known, no other formation in the Livingstone range carries bituminous matter indigenous to the formation. It is, however, possible, that certain zones of the Cretaceous rocks of the Great Plains carry indigenous oils.

To explain the Waterton lake and Oil creek seepages, I adopted in the field a tentative hypothesis involving the immense Front range thrust-fault called by Mr. Willis the 'Lewis Thrust.' At and near the 49th parallel the strong, rigid pre-Cambrian beds have been pushed bodily out over the weaker Cretaceous strata of the plains for a distance of several miles. Farther south in Montana, Mr. Willis has demonstrated that the whole Lewis range has similarly migrated as a single block thrust at least seven miles over the yielding floor of the plains. A hundred and fifty miles to the north-northwest, Mr. McConnell long ago proved the existence of a similar overthrust in the gaps of Bow river and Ghost river. It is owing to such an overthrust that the very oldest formation known in the vicinity of Waterton lake (the pre-Cambrian 'Altyn Limestone') overlies the very youngest bed-rock formation of the region (Cretaceous). Far below the thrust-surface and underlying the Cretaceous is the 'Devono-Carboniferous' limestone. By the tentative hypothesis mentioned, the oil seepages of this district are supposed to be due to the rising of oil from the limestone or from some petroliferous zone in the Cretaceous, upward through fissures in the overlying pre-Cambrian block. I have since learned that Mr. Willis had independently come to the same view of the various oil occurrences on the eastern slopes of the Lewis and Livingstone ranges.

This hypothesis, if correctly matching the real facts, has an important bearing on the location of oil prospects. If the pre-Cambrian rocks truly form a huge cover upon potentially oil-bearing Cretaceous or other strata, it is clear that boring should be directed with due regard to the position and shape of the thrust-surface underlying that cover. Preferably the drill should go down where the thrust-surface or at least the strata of the relatively impervious cover are bent into anticlinal warps or folds and as near the summits of the folds as possible. Further, since the great thrust-surface seems to dip westward, it is also manifest that the bore-hole should not be located so far within the range as to compel the penetration of an inordinate thickness of the hard cover. At the same time it cannot too often be repeated that seepages do not necessarily mean an oil-field. In fact, the more numerous the seepages, the greater is the danger that the underground reservoirs have, in the course of ages, become largely depleted of oil. Structural geology must recognize the possibility of large oil deposits along the eastern foot of the Rockies, but the anatomy of the range is so peculiar, and the significant underground structures, especially the relations and attitude of the thrust-surface so difficult of determination, that it is impossible to indicate the best locations for test borings in other than the most general terms. This much is certain that no one, by virtue of any amount of experience in other oil fields, can forecast either success or failure for prospecting companies in the Alberta field. The structure of the field is unique. All that the structural geologist can do in this instance is to declare the findings of a surface study of the country and to suggest for preliminary boring certain localities favoured as a result of such study. Common sense teaches that, if boring is to be undertaken at all, the drill should go down where the rock-structures deducible from surface rock-croppings seem most likely to have led to the accumulation of oil. Just as surely common sense teaches that, in this particular field of Alberta, the underground arrangement of the rocks cannot in its details, be deduced from surface croppings. For those details the structural geologist is as dependent upon trial borings as the prospector himself.

The future of the Flathead field is still more difficult of forecast. A thick mantle of glacial drift so completely covers the bed-rock of the Flathead valley that rock-out-

crops are exceedingly rare. Prospecting in the valley has therefore been blind, and blind it must remain unless the treacherous seepages be considered as guides. It is not impossible that the great thrust-fault of the eastern slopes of the Rockies is really continuous beneath the whole of the Livingstone range, so that the pre-Cambrian beds of the Flathead slope have been thrust over the 'Devono-Carboniferous' limestone or other organic formation. Or, secondly, it is possible that this stratigraphic relation has been produced by a local thrust similar to, but not identical with, the proved thrust on the east. Yet neither of these suppositions is as yet capable of proof from the surface study of the rocks. Neither of them would probably ever have been suggested were it not for the existence of the Flathead oil seepages and for the fact that natural gas has, for more than two years, been steadily blowing from the hole bored in the pre-Cambrian argillites and quartzites at Lower Kintla lake. This particular occurrence of oil and gas is nothing more nor less than a complete puzzle which apparently will be cleared up only after slow and costly experiments with actual boring.

The work of the second part of the season fell into two parts, according to a natural division of the boundary belt covered. From the heights east of Osoyoos lake to the canyon of the Pasayten river, a distance of sixty miles, the geological section runs continuously through plutonic, intrusive rocks. In 1901 a reconnaissance study of these was made by Messrs. Smith and Calkins of the United States Geological Survey, who found that the same rocks extend far to the south of the boundary line. They together form an igneous complex which is yet a unit in the structure of the whole range. After the manner of many a large mass of homogeneous granite, this complex displaces, or more truly expressed, replaces the older, non-igneous formations that once composed these mountains. The whole complex mass may be called the Okanagan batholith. It was found to include nine different large bodies of granitic, syenitic or peridotitic rock. Four of the bodies are of batholithic dimensions themselves; the other five are of stock dimensions. At least seven different periods of intrusion, exclusive of those represented in the many injected dikes, are illustrated in the development of the whole composite batholith. Abundant rock-exposures and the specially favourable conditions of field-work, made it possible to delimit with considerable accuracy the various component members of the batholith.

West of the Pasayten is the other division of the belt covered this season in the Cascades. In largest part it is underlain by an extremely thick, apparently conformable series of arkose-sandstones, conglomerates and argillites bearing fossils of Cretaceous age at various horizons. The series totals nearly 30,000 feet in thickness. Its basal beds rest on a zone of pre-Cretaceous, secular weathering in granite, one of the oldest component members of the Okanagan batholith. The Cretaceous series is, however, cut by stocks of granite believed to be of the same age as the youngest members of the batholith.

One of these stocks has the most perfectly exposed contacts I have ever seen about a granite body. The stock occurs in a very rugged, deeply canyoned portion of the range forming the main Cascade water-divide. At many points about the entire periphery of the stock, the surface of contact between the granite and the invaded sediments can be followed with the eye or with the hammer through vertical descents of from 700 to 2,200 feet. It was invariably found that the plunging contact-surface sloped outward with reference to the centre of the granite as now exposed. I do not know of there being anywhere described such a telling illustration of the downward enlargement of igneous stocks. The evidence is equally well displayed that this granite, in assuming its present position, actually replaced the Cretaceous sandstones and argillites. The sedimentaries were already strongly tilted before the intrusion began. Their regional dip and strike were essentially unaffected by the advance of the granite magma. It seems quite without question that here, in some way or other, the magma ate its way up through the sedimentaries so as to form the subterranean chamber now filled with the crystallized granite. Similar evidences of downward enlargement and of magmatic incorporation are also illustrated on a large scale in the Okanagan batholith. The primary importance of these facts, as bearing on principles of general and

economic geology, warrants their being noted even in a brief report of the season's operations.

The thicknesses, structures and lithological composition of the members of the Cretaceous series were determined. Fossils were collected at six horizons. The whole series is cut off on the west by a master fault running along the eastern base of the Hozomeen ridge. From that fault to the Skagit the rocks are chiefly serpentines, green-stones and cherty quartzites, enormously crushed and believed to be upper Palæozoic in age.

This season the extreme eastern and extreme western limits of the great Cordilleran ice-cap of the glacial period were located for the 49th parallel. It is now possible to construct a complete profile showing the width and varying depth of the ice-cap in this latitude.

I have the honour to be, sir,
Your obedient servant,

REGINALD A. DALY.